Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

COMPARATIVE HISTOLOGY OF FRUITS AND SEEDS OF CERTAIN SPECIES OF CUCURBITACEAE

KATE G. BARBER

(WITH FIFTY-THREE FIGURES)

Introduction

This investigation was undertaken with the view to supplementing the work already done on the histology of the fruits and seeds of Cucurbitaceae. The literature, although not meager, treats only of the most conspicuous elements of the spermoderm, ignoring, with a few exceptions, the less important tissues of the seed and the whole of the pericarp.

In the following paper are included additions to the histology of the spermoderm and new descriptions of the pericarps of the common species; also brief descriptions of six interesting seeds previously undescribed.

I wish to acknowledge my great indebtedness to Dr. A. L. WINTON, under whose guidance and inspiration this work was carried on, and also to Professor A. W. EVANS for advice in its preparation.

Résumé of the literature

In 1833 BISCHOFF[1] published two cuts showing cross-sections of the seed coats of *Cucurbita Pepo* and *C. Lagenaria*, which, according to FICKEL,[2] leave much to be desired with regard to detail.

VON HÖHNEL[3] was the first to publish a detailed description of the seed coats of the Cucurbitaceae, the species studied being *Cucurbita Pepo* L., *Lagenaria vulgaris* Ser., and *Cucumis sativus* L.

A thorough investigation of the integuments, from before fertilization of the flower until maturity, led him to conclude that: (1) the inner integument (three to four layers thick) develops but slightly, becoming the collapsed, thin-walled inner parenchyma of the seed coat; and (2) the outer integument (eight to ten layers thick) forms the greatly differentiated outer layers of the coat.

---

[1] Handbuch der bot. Terminologie und Systemkunde. *pl. 43. figs. 1872, 1873A.*

[2] Ueber die Anatomie und Entwickelungsgeschichte der Samenschalen einiger Cucurbitaceen. Bot. Zeit. 34:738. 1876.

[3] Morphologische Untersuchungen über die Samenschalen der Cucurbitaceen und einiger verwandter Familien. Sitzb. Akad. Wiss. Wien, Mathem.-Naturw. 73:297. 1876.

At maturity he found that the spermoderm consists of a complicated structure with five distinct tissues, namely: (1) inner epithelium of the carpel; (2) outer and (3) inner integument; (4) perisperm; and (5) endosperm. These five in turn are subdivided into ten layers, each one to many cells thick. About the edge of the seed, between the fifth and sixth layers, runs the small raphe.

This author divided the family into two large groups. In the first belong those seeds with the epithelium of the carpel firmly attached to the spermoderm, represented in his work by *Cucurbita Pepo* and *Lagenaria vulgaris.* The second includes the species without this epithelium, illustrated by *Cucumis sativus.* Otherwise there are no great differences in development.

In the same year, one month after the appearance of VON HÖHNEL'S paper, FICKEL[2] published his inaugural dissertation, describing the seed coats of *Cucumis sativus* L., *C. Dudaim* L., *C. myriocarpus* Naud., *Cucurbita Pepo* L., *C. melanosperma* A. Br., *Lagenaria vulgaris* Ser., *Citrullus vulgaris* Schrad., *Benincasa cerifera* Savi., *Bryonia alba* L., *B. dioica* L., *Ecballium agreste* Rchb., *Sicyos angulatus* L., *Cyclanthera explodens* L., *C. pedata* Schrad., and *Bryonopsis erythrocarpa.* He gives descriptions and cuts of the mature seed coat and its development from the two integuments, and reaches the following conclusions: (1) the seed coat has five layers; (2) the epidermal cells are radially elongated and, with the exception of those of Sicyos and Cyclanthera, have thickenings of various kinds on the radial walls; (3) the second layer consists of one or more layers of cells varying in size and thickness of walls; (4) a third layer has either radially or longitudinally elongated cells; and (5) the remaining layers are of compressed cells without definite structure.

GODFRIN[4] briefly notes the seed coats of *Cucumis sativus* L., *Cucurbita maxima* Duch., *Lagenaria vulgaris* Ser., *Sicyos angulatus* L., and *Cyclanthera pedata* Schrad. In his general description the spermoderm is represented as having six layers, as follows: (1) epidermis of prismatic cells; (2) small cells differing as to number, size, and thickness of walls; (3) a single layer of sclerenchymatized cells varying but slightly in all the species; (4) outer and inner parenchyma; (5) inner epidermal cells, often separated from the preceding layer by longitudinally elongated cells; and (6) inner row of thick-walled cells with granular contents, the author evidently including the endosperm in the spermoderm. This is followed by a description of each of the species already mentioned.

---

[4] Etude histologique sur les téguments séminaux des angiospermes. Soc. Sci. Nancy **1880**:160.

VON HÖHNEL'S division of the family into two groups, distinguished by the presence or absence on the spermoderm of the inner carpellary layer, is criticized, as GODFRIN always found this layer present in fresh material. He used the following grouping, based on the elongation of the cells of the "protective" (third) layer: (1) tangentially elongated cells (Cucumis, Lagenaria, Cucurbita, Citrullus); and (2) radially elongated cells (Sicyos and Cyclanthera). The individual descriptions are brief, many details being omitted.

FISCHER[5], in his classical work on sieve tubes of the Cucurbitaceae, describes a detailed study of the elements in all parts of the plant. The tubes are of four kinds: (1) bundle sieve tubes (usual type found in fibro-vascular bundle); (2) ectocyclic (isolated tubes of hypoderm); (3) entocyclic (isolated tubes of the inner tissues); and (4) commisural (connecting those of the bundle with the isolated tubes). In the young isolated tubes the contents are thickened but in the old there is a watery slime secreted by the neighboring cells. These isolated tubes, being free from callus plates, were mistaken by earlier writers for latex tubes.

Six plates are given illustrating these tubes in *Cucurbita Pepo*, *Lagenaria vulgaris*, *Sicyos angulatus*, *Cyclanthera pedata*, *Melothria pendula*, *Bryonia alba*, and *Luffa pentandra*.

T. F. HANAUSEK[6] gives chemical analyses of *Cucumis sativus* L., *C. Melo* L., *C. Citrullus* L., *Cucurbita Pepo* L., and *C. maxima* Duch., and mentions briefly the histology of each.

HARZ[7] describes and illustrates cross-sections of species of Cucumis, Citrullus, Lagenaria, and Cucurbita. The numerous species are divided into races, varieties, and subvarieties, with long lists of synonyms under each. The author briefly notes the macroscopic appearance of the fruit, then gives short histological descriptions of the seed. According to his division the spermoderm has five layers. Some of the details of structure of the outer layers, and nearly all of the inner ones, are omitted.

---

[5] Untersuchungen über das Siebröhren-System der Cucurbitaceen. Berlin. 1884.

[6] Die Nahrungs- und Genussmittel aus dem Pflanzenreiche 195. Kassel. 1884.

[7] Landwirthschaftliche Samenkunde 767. Berlin. 1885.

VOGL[8] devotes but a single paragraph to a microscopical description of Cucurbitae.

BRAEMER[9] in 1893 studied the stem, leaf, pericarp, and seed of *Bryonia dioica* Jacq., *Ecballium Elaterium* Rich., and *Citrullus Colocynthis* Schrad., but confined his attention chiefly to a microchemical investigation of the contents of the sieve tubes and latex tubes, both of which he regards as latex tubes, accepting the descriptions of the tissues given by earlier writers. According to his introduction, the pericarp has an outer and inner epidermis with a sarcocarp between. Within the spermoderm, having hard and lignified layers, are inclosed an embryo, reduced to a small radicle and two cotyledons, rich in oil and aleurone grains, and the remains of the perisperm and endosperm.

The main part of the paper is devoted to the long, ramifying, straight or sinuous tubes containing a yellow semi-fluid, finely granular, refractive substance which entirely fills the cavity. Both lateral and cross walls are composed of cellulose without any indications of sieve or callus plates. In their morphological and chemical characters they resemble the latex tubes of Convolvulaceae and Campanulaceae, and the isolated sieve tubes of FISCHER. In these tubes BRAEMER found the three "active principles" bryonin, colocynthin, and elaterin.

PLANCHON and COLLIN[10] treat the species used as drugs. Macroscopic and microscopic sections are figured, but no histological details are given, of the fruits and seeds of *Cucurbita Pepo* Duch., *Citrullus Colocynthis* Schrad., *Cucumis sativus* L., *Ecballium Elaterium* Rich., and Fevileae.

VILLIERS and COLLIN[11] use the bicollateral bundles and sieve tubes (or latex tubes) in the detection of pumpkin pulp as an adulterant of preserves. They have an original cut, but their description of these elements is taken from FISCHER[5] and BRAEMER.[9]

---

[8] Pharmakognosie 196. Wien. 1892.

[9] De la localisation des principes actifs des Cucurbitacées. Toulouse. 1893.

[10] Les drogues simples d'origine végétale 2:292. Paris. 1896.

[11] Traité des altérations et falsifications des substances alimentaires 454. Paris. 1900.

T. F. HANAUSEK[12] gives one figure illustrating the characteristic elements of the seed of *Cucurbita Pepo* L., *C. maxima* Duch., and *C. moschata* Duch. These elements are the *Skleriden* (resembling the epidermis of Spanish pepper), spongy parenchyma, starch grains of the inner parenchyma, endosperm and cotyledon tissue with aleurone grains.

ARTHUR MEYER[13] refers briefly to the aleurone grains of *Cucurbita Pepo* as having a diameter of 1–4 μ (mostly 3 μ) and small crystalloids. In his table taken from LUDTKE,[14] the seeds of Citrullus and Colocynthis are stated to contain numerous aleurone grains 1–7.5 μ in diameter, each having one globoid (0.5–1 μ) and one crystalloid (1–3 μ).

BÖHMER[15] gives a chemical analysis of the seeds of the Cucurbitae and one figure showing a cross-section and surface view. His brief histological description is taken from other authors.

COLLIN and PERROT[16] describe briefly and give a cross-section of the seed of *Cucurbita Pepo* Duch.

According to MOELLER[17] the fruits of Cucurbitaceae are all large berries with hard shells, soft fruit-flesh, and many seeds. The seed coat is divided into four tissues: (1) palisade cells with thickenings on radial walls; (2) stone-cell layer; (3) stellate parenchyma; and (4) thin-walled parenchyma. A brief description follows of *Cucurbita Pepo* L., *C. maxima* Duch., *C. moschata* Duch., *Cucumis sativus* L., *C. Melo* L., and *Citrullus vulgaris* Schrad., with cuts of the last two.

---

[12] Lehrbuch der technischen Mikroskopie 370. Stuttgart. 1901. Translation, WINTON, The microscopy of technical products 369. New York. 1907.

[13] Die Grundlagen und die Methoden für die mikroskopische Untersuchung von Pflanzenpulvern 32. Jena. 1901.

[14] Ueber die Beschaffenheit der Aleuronkörner einiger Samen. Ber. Deutsch. Pharm. Gesells. **1891**:56–59.

[15] Die Kraftfuttermittel, ihre Rohstoffe, Herstellung, Zusammensetzung, Verdaulichkeit und Verwendung, mit besonderen Berücksichtigung der Verfälschungen und der mikroskopischen Untersuchung 508. Berlin. 1903.

[16] Les résidues industriels 270. Paris. 1904.

[17] Mikroskopie der Nahrungs- und Genussmittel 470. 2. Aufl. Berlin. 1905.

BARBER,[18] in a chapter on Cucurbitaceae, gives brief descriptions of *Cucurbita Pepo* L., *C. maxima* Duch., *Cucumis sativus* L., *C. Melo* L., and *Citrullus vulgaris* Schrad., illustrating the first-named species by three original cuts.

Geographical distribution

The Cucurbitaceae are scattered over the greater part of the earth's surface, but reach their highest development in the tropics. Representatives are, for the most part, absent in the colder regions of the temperate zone, the two exceptions being *Sicyos angulatus*, found in Canada, and *Echinocystis lobata* in New England.

The total number[19] of genera is eighty-five, the Old World claiming fifty-four and the western hemisphere thirty-eight, while seven are common to both. Under each there are long lists of species, subspecies, and varieties, authors differing greatly as to the number.

EDIBLE SPECIES.—Many species have long been cultivated for food. Probably one of the oldest on record is Citrullus (watermelon), a favorite with the ancient Egyptians. Other important species are *Cucumis sativus* (cucumber), eaten in China as a vegetable more than two centuries before the Christian era; *Cucurbita Pepo* (pumpkin), grown by the aborigines in America; and *Cucumis Melo* (musk melon), greatly prized in Asia and Africa. These have now spread to all the warmer regions of the earth.

ORNAMENTAL SPECIES.—There are many varieties grown for the curious form and vivid coloring of the fruit, among which are *Momordica balsamina* (balsam apple), *Lagenaria vulgaris* Ser. (common gourd), *Cucumis erinaceus* (hedge-hog gourd), *Cyclanthera explodens* (squirting cucumber), and *Luffa cylindrica* (dish-cloth gourd).

PHARMACEUTICAL SPECIES.—Among those used for drugs, both here and in Europe, are *Bryonia dioica* (bryony), *Citrullus Colocynthis* (colocynth), and *Ecballium Elaterium* (elaterin).

General characters

MACROSCOPIC

FLOWER.—The axillary flowers, yellow or white in color, are borne either solitary or in groups of various kinds. They are usually monoecious, epigynous; calyx and corolla actinomorphic, adnate at the base. The stamens are five in number, four of which frequently cohere in pairs, or more rarely they all unite to form a column. The ovary is one- to five-, usually three-celled.

---

[18] In WINTON, Microscopy of vegetable foods 401. New York. 1906.

[19] ENGLER UND PRANTL, Pflanzenfamilien IV. 5:9.

FRUIT.—In the Cucurbitaceae are found the largest fruits of the whole plant kingdom. From the enormous berry of Cucurbita, reaching a maximum of several kilos in weight, there are all gradations down to the small burr of *Sicyos angulatus*, only slightly larger than the single inclosed seed.

The fruits are nearly always fleshy berries; they may, however, become membranaceous and dry, preserving at the same time their original shape. There is no characteristic form for the family, the shape differing as much as the size. All possible variations of spherical, elliptical, greatly elongated, and curious unsymmetrical forms are represented. They are smooth, warty, or covered with spines, or various other kinds of emergences. In addition to these outgrowths, the young fruits of all the common species bear one or more forms of hairs which, in most cases, persist at maturity. The color varies from white, green, and yellow to red, with spots and stripes on some of the varieties.

All the fruits described in this paper are indehiscent with the exception of Echinocystis, which bursts irregularly at the top.

The pericarp, or rather the pericarp and adherent receptacle, varies in thickness (thin or thick rind, or solid fruit-flesh), color (white, green, yellow, or red), and texture (watery or dry, sclerenchymatized or soft). The central placentae extend to the outer wall and divide, turning back so as to give a parietal appearance.

SEED.—The seeds, borne either singly or in great numbers, are anatropous, large, ovate, and flattened, with or without a border (formed by elongated epidermal cells) on each side at the edge. They vary in shape from the narrow and pointed to the broad, rounded, or rectangular forms, and in color from white to brown and black.

MICROSCOPIC

PERICARP.—The pericarp may be divided into six, more or less distinct tissues as follows:

1. *Epicarp.*—The cells are for the most part polygonal, forming

a palisade layer, those about the stomata being frequently elongated. The outer and radial walls are cuticularized and occasionally colored.

2. *Hypoderm.*—Few or many layers of isodiametric cells form the tissue beneath the epicarp. The cells are somewhat thickened and occasionally pitted.

3. *Outer mesocarp.*—Isodiametric cells with either cellulose, or sclerenchymatized and pitted, walls (stone cells, etc.) form a sharply defined zone varying from a few to many cells in thickness.

4. *The middle mesocarp* consists of large, usually isodiametric, thin-walled cells, often turgid with a watery cell sap and containing a small amount of starch. The starch grains are small, with an average diameter of 10 μ. They are truncated, frequently occurring in aggregates of two and three, with slightly eccentric hilum and faint rings. Polarization crosses are very distinct.

5. *Inner mesocarp.*—Several layers of thin-walled cells, forming this tissue, closely resemble the preceding layers. The cells are small and have no visible contents.

6. *Endocarp.*—Very small, thin-walled, tangentially elongated cells, arranged side by side in groups, form a thin transparent tissue. With the exception of Cucumis, this layer remains so firmly attached to the dry seed that some authors describe it as the outer layer of the spermoderm.

The anastomosing *bundles* occurring throughout the mesocarp are bicollateral. They are either small and soft, or large and stiff, forming a conspicuous network. The elements consist of spiral, annular, and reticulated vessels, and sieve tubes having large sieve plates evident without staining.

Isolated sieve tubes and latex tubes.[20]—FISCHER[5] claims there are no true latex tubes, those known by this name being simply sieve tubes that have ceased to function; BRAEMER[9] and other later authors, however, use the term "latex tubes." I have seen the perforated plates in some tubes and have not found them in those containing granular milky contents which harden in alcohol, therefore shall mention both in the following descriptions. These elements occur in considerable numbers throughout the middle tissues of the pericarp.

---

[20] According to DE BARY (Comparative anatomy of the vegetative organs of the phanerogams and ferns 198. Oxford. 1884) DIPPEL finds the septa and lateral walls of articulated tubes provided with sieve plates and thinks them intermediate between sieve tubes and latex tubes. DE BARY himself finds not the plates but perforations scattered over the whole wall, and further states that there are two kinds of latex tubes which do not correspond in function: (1) those secreting tannin, etc., and (2) those (of milky plants) which are closely related to sieve tubes.

Each seed has a firm spermoderm of many layers, a thin collapsed perisperm and endosperm, and a large embryo consisting of two large, flat, leaf-like cotyledons and a small radicle.

SPERMODERM.—Authors variously state the number of layers in this leathery coat or shell as four[17] to ten.[21] I myself consider it as consisting of five distinct tissue layers, the second being occasionally differentiated into two, and the fourth often into two or three forms of cells arranged in as many layers. It is developed from the two integuments (*fig. 10*), the outer integument forming the three outer and part of the fourth layers, the remainder of the coat developing from the inner integument.

1. *The epidermis* consists of a single layer of prismatic palisade cells, polygonal in surface view. They are usually of equal height over the flat surface of the seed, increasing in height at or on both sides of the edge. The radial walls of a few species (as *Echinocystis lobata*) are uniformly thickened; in all the other seeds they have either straight or branched thickenings running from the inner to the outer tangential walls. The outer walls, and frequently the inner, are thickened.

VOGL,[8] the only author that notes the presence of starch in this layer, gives no description of the grains. According to my own observation they are small, globular, reaching a maximum diameter of 7 μ, the larger ones showing a central hilum but no rings. They polarize very indistinctly.

2. *Subepidermal layer.*—One or more layers of sclerenchymatized cells, varying greatly in size and shape, make up this layer. The cells are either small, pitted, without intercellular spaces (Cucurbita), or longitudinally elongated, arranged end to end in rows, with numerous characteristic intercellular spaces (Cucumis), or form a thick layer of greatly thickened irregularly arranged cells. No contents are evident.

3. *Sclerenchyma.*—This consists of a layer of exceedingly thick-

---

[21] ENGLER UND PRANTL, Pflanzenfamilien IV. 5:8.

walled cells elongated either tangentially and arranged end to end in longitudinal rows, or radially forming a palisade layer. The walls are sinuous with numerous pits, and after maceration the margins of the outer and inner tangential walls are seen to be lobed, each lobe branching with the ends overlapping and fitting together to form a flat compact layer (*fig. 18*). The empty cell cavities are comparatively small and present a striking oval appearance in median section.

4. *Parenchyma.*—Many cell layers of spongy parenchyma, differing greatly in size and shape, make up this layer. The cells of the outer layers are usually small and frequently sclerenchymatized and pitted. Within these small cells are one or more layers of either large or small stellate cells having very large intercellular spaces. Their thin walls are usually sclerenchymatized and often pitted or reticulated (Cucurbita). The remaining layers consist of small, thin-walled spongy parenchyma cells containing chlorophyll in some species.

The small raphal bundles are found imbedded in this parenchyma usually about the edge only; a few exceptions, however, show branches on the flattened surface of the seed.

5. *Inner epidermis.*—A single layer of small, polygonal, and inconspicuous thin-walled cells forms the inner tissue.

PERISPERM.—This thin coat is collapsed in the mature fruit, but treatment with Javelle water brings to view several layers of small, very thin-walled cells covered with an epidermis having cuticularized outer and radial walls. No contents are evident.

ENDOSPERM.—This consists of one layer of very thick-walled polygonal cells, containing oil and protein granules. A few exceptions (as *Citrullus vulgaris*) have within this layer several more layers of empty thin-walled cells.

EMBRYO.—The leaf-like cotyledons have an epidermis of small cells below which, on the inner side, are two sharply defined palisade layers. Procambium bundles run through the small-celled mesophyll. All of the cells are filled with oil and protein granules containing globoids and crystalloids which are very minute and of practically no diagnostic importance.

Specific characters

CUCURBITA PEPO L.

Cucurbita Pepo L. (pumpkin), according to the earlier writers, was introduced from southern Asia, but WITTMACK, in his recent investigations of prehistoric remains in Peru, claims it to be a native of America. Early explorers also recorded the cultivation of this fruit by the aborigines in their maize fields.

The fruit is one of the largest of the Cucurbitaceae, occasionally reaching a weight of 200 kilos. It is a smooth, apple-shaped berry, with about twenty, more or less pronounced, longitudinal grooves, the color varying from yellowish green to orange. There are many subspecies, differing greatly in size and shape, of which HARZ enumerates thirty. Among them are the small to enormously large spherical, ellipsoidal, flask-, egg-, J-, and curiously-shaped forms. Most of the larger ones are cultivated for food, the smaller as ornamental fruits.

At maturity the fruit consists of a hollow, yellow rind, 2–3^{cm} in thickness, containing a tangle of slimy fibers, among which are the numerous flattened seeds.

The white seeds (*fig. 1*) are 1.5–2.5^{cm} in length, elliptical, flattened, and have a narrow border about the edge on both sides.

PERICARP.—This makes up the bulk of the fruit. It includes the rind and fibers, the connecting parenchyma breaking down before the fruit reaches maturity.

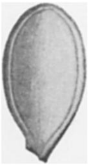


FIG. 1.—*Cucurbita Pepo* L. Seed. ×1.

1. *Epicarp* (*figs. 2, 3, epi*).—The prismatic cells form a palisade layer about 50μ in height, with outer and radial walls greatly thickened, cuticularized, and colored bright yellow. In surface view they are polygonal (14μ in diameter), except at characteristic white spots about which they are elongated and curved. These white spots consist of a stoma of the common type, from which radiate rows of tangentially elongated epidermal cells. The stomata are not uniformly distributed and occasionally two are found in the same group of radiating cells.

On the very young fruit, even before the fertilization of the ovary, two forms of hairs are found (*fig. 3*). Both arise from a foot-cell differing from the neighboring epidermal cells only in the more rounded shape. The hairs dry up and disappear while the fruit is still very small, leaving the foot-cell intact. Later the epidermal cells divide, thicken their walls, and press against the foot, which thus becomes polygonal. As both kinds of cells are of the same size, the two are indistinguishable, which accounts for the absence of hair scars on the mature fruit.

The first form of hair is jointed (t^1) and of great size, often reaching a length of 1.5–2^{mm}. The diameter increases rapidly (up to about 85 μ) for a short distance from the foot, then gradually tapers, forming a long, thick-walled (5 μ), conical hair. The first few cells are two or three times as broad as long, while the following cells become elongated as the hair increases in size.

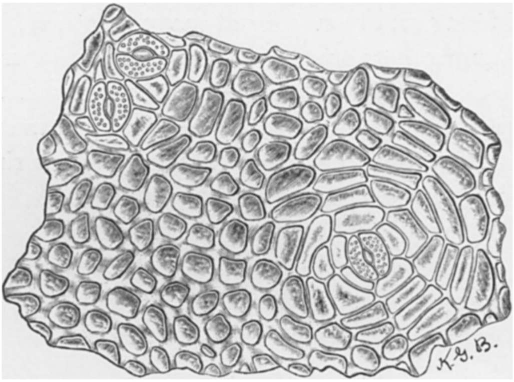


FIG. 2.—*Cucurbita Pepo* L. Epicarp in surface view. ×320.

The second form is capitate (t^2), and like the first increases in diameter from the foot, forming a jointed stalk of four or five cells. It ends with a large spherical head of one or more cells, often 54 μ in diameter.

2. *Hypoderm.*—Many cell layers of exceedingly small, isodiametric cells, 20 μ in diameter, form this layer. The cells have thick walls, occasional pits, and small intercellular spaces. The visible contents consist of numerous protein granules. This layer closely resembles the corresponding one of *C. Pepo* var. *verrucosa* Naud. (*fig. 7, hy*).

3. *Outer mesocarp.*—Within the preceding layer is a region composed of cells graduating in size from the small cells of the hypoderm

to the large ones of the middle mesocarp. They are isodiametric, have thick walls and intercellular spaces, and but few contents.

4. *Middle mesocarp* (*fig. 4*).—In this layer the cells become gradually larger, thicker-walled, and more loosely arranged. They contain small starch grains (*am*), reaching a maximum size of 10 μ. The outer cells contain a considerable number of these grains, but the increase in size of the cells is accompanied by a decrease in amount of starch.

5. *Inner mesocarp.*—This layer consists of rather large-celled parenchyma with no evident contents.

Bundles and isolated sieve tubes, together with anastomosing latex tubes (*lat*) are found throughout the mesocarp, while in the center of the fruit there is a great mass of tough fibers, surrounded by the remains of the broken-down parenchyma.

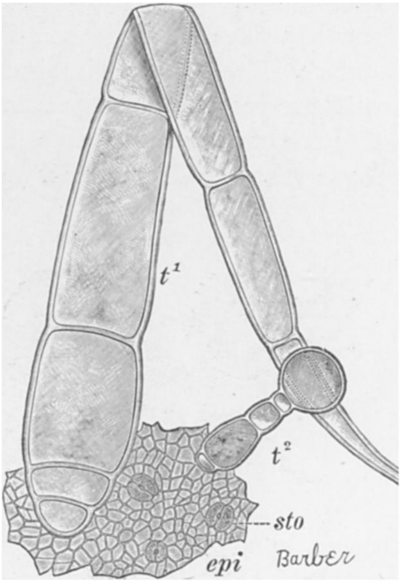


FIG. 3.—*Cucurbita Pepo* L. Immature epicarp in surface view; *epi*, epicarp with t^1, jointed conical hair, t^2, capitate hair, and *sto*, stoma. × 160.

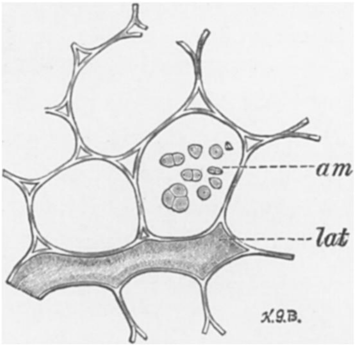


FIG. 4.—*Cucurbita Pepo* L. Cross-section of mesocarp showing *am*, starch grains, and *lat*, latex tube. × 160.

6. The *endocarp* appears on the seeds as a thin membrane of longitudinally elongated cells, arranged end to end in rows. The inner wall is about the same thickness as the outer wall of the epidermis of the spermoderm, to which it is quite firmly attached; from the dry seeds, however, it may be readily separated as a thin, transparent, colorless skin.

SPERMODERM (*figs 5, 6*).—The five layers making up the spermoderm are as follows:

1. *Epidermis* (*ep*).—The prismatic cells form a continuous layer without intercellular spaces. They are radially elongated, on the flat side of the seed to 270 μ, on the edge to 50 μ, while the border consists of a ridge of cells several times as high as those of the flattened surface. The outer wall is thickened, but has no cuticle, and the radial walls are very thin, with peculiar branching thickenings of cellulose. The thickenings run from the base of the cell, one on each wall, as single straight rods until near the outer wall, where they branch profusely, giving rise to a beaded appearance in tangential section. After maceration, or in scrapings of the spermoderm, the rods fall upon their sides, presenting the appearance shown in *fig. 5*, ep^1. In dry seeds the walls of this layer are frequently broken down, and only a few of the thickenings remain, which may be mistaken for the cut surface of the walls themselves.

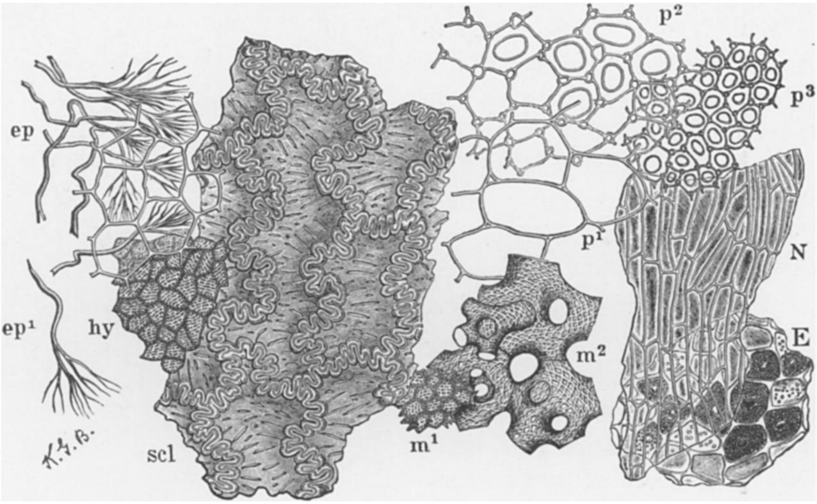


FIG. 5.—*Cucurbita Pepo* L. Seed elements in surface view; *ep*, ribbed palisade cells of epidermis; ep^1, isolated rib; *hy*, subepidermal layer; *scl*, sclerenchyma; m^1, pitted parenchyma; m^2, reticulated spongy parenchyma; p^1, parenchyma; p^2, spongy parenchyma; p^3, inner epidermis of spermoderm; *N*, perisperm; *E*, endosperm. ×160.

Round starch grains (*am*), up to 7 μ in diameter, of the type already described, occur in considerable numbers in the epidermal cells.

2. *Subepidermal layer* (*hy*).—Below the epidermis is a layer of

small, polygonal, somewhat elongated cells, about 25 μ in diameter, with numerous minute pits, giving the walls a beaded appearance. This layer, without intercellular spaces, is three to five cells thick, the number increasing toward the edge of the seed.

3. *Sclerenchyma* (*scl*).—Firmness is given to the spermoderm by one layer (over the edge two or three) of longitudinally elongated (250 μ) cells, arranged end to end in rows. In surface view, both side and end walls are sinuous, often reaching 20 μ in thickness. After maceration and by careful focusing, the outer and inner surfaces of these cells may be seen to send out remarkable ramifications, whose dichotomous branches overlap one another. In transverse section the oval appearance of the cell cavity is a characteristic feature. A few pits may be seen with a high power.

4. *Parenchyma.*—There are three quite distinct layers, the parenchyma showing the greatest differentiation in this species. In contact with the sclerenchyma is the first layer of small pitted cells, with few or no intercellular spaces (m^1). Resting on this compact layer, either singly or in groups, are larger cells, which stand out like branches in the intercellular spaces of the next layer.

The cells of the second layer are characteristic of the genus (m^2). In this species the layer is two cells thick, with intercellular spaces so large that they form a great cavity in which the cells are suspended. In form the cells are somewhat stellate, joining the preceding layer by one branch or a similar but smaller cell. The walls are beautifully reticulate, the thickenings following a definite course around the curved surface of the cell. The cross walls are netted in a similar manner but with a somewhat larger mesh.

The true spongy parenchyma consists of a number of layers of somewhat collapsed cells, but treatment with Javelle water expands the tissues so that they may be easily studied. The cells are thin-walled, decreasing in size toward the inner epidermis (p^1, p^2). In surface view the contour of the branches appears, in the center of the cells, as rings nearly as large as the cells themselves. A green color is given to these inner layers by chlorophyll.

5. The *inner epidermis* (p^3) is composed of small, thin-walled cells.

PERISPERM (*figs. 5, 6, N*).—In this coat there are about six layers of thin-walled cells with longitudinally elongated, cuticularized, epidermal cells.

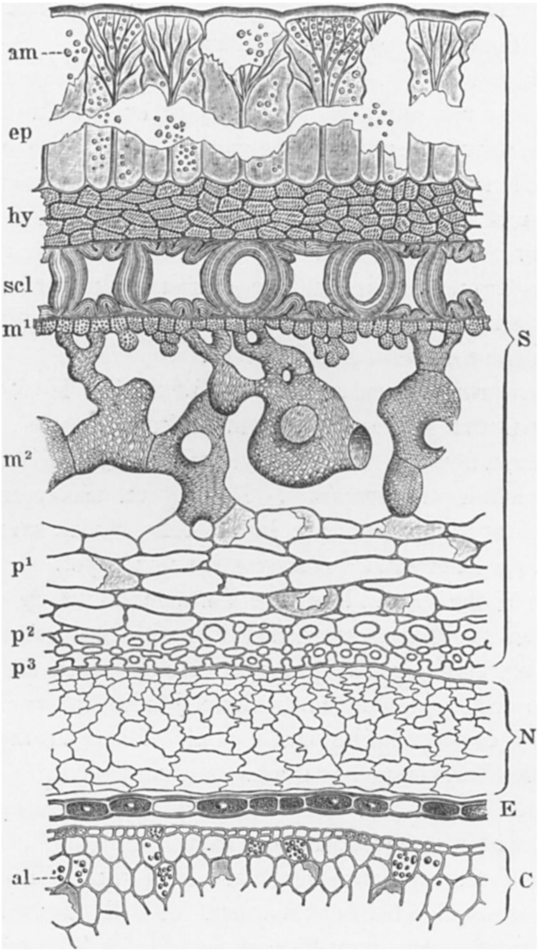


FIG. 6.—*Cucurbita Pepo* L. Seed in cross-section; *S*, spermoderm consisting of *ep*, ribbed palisade cells of epidermis containing *am*, starch grains, *hy*, pitted subepidermal layer, *scl*, sclerenchyma, m^1, pitted parenchyma, m^2, reticulated spongy parenchyma, p^1, parenchyma, p^2, spongy parenchyma, and p^3, inner epidermis; *N*, perisperm; *E*, endosperm consisting of aleurone cells; *C*, cotyledon containing *al*, aleurone grains. ×160.

ENDOSPERM (*figs. 5, 6, E*).—This consists of a single layer of cells with thickened walls, containing granular protoplasm and a large central nucleus.

EMBRYO.—The cotyledons (*C*) have small epidermal cells on both surfaces and two layers of palisade cells within the inner epidermis. Aleurone grains (*al*) up to 6 μ, containing globoids and crystalloids, also oil, are found in all the cells.

C. PEPO VAR. VERRUCOSA NAUD.

This variety, the crook-necked squash, has a rather large flask-shaped fruit, with the neck showing a distinct curve or crook. Longitudinal grooves occur frequently, but are not so well marked as in *C. Pepo.* There is a hard rind, yellow or orange in color, covered with very pronounced warts and filled with bundle fibers. The central parenchymatous tissue breaks down only in the swollen base, the neck not expanding enough to tear the tissues apart.

The seeds, of a dirty white color, are not over 2^{cm} long, smooth, and flattened, with a border at the edge.

PERICARP (*fig. 7*).—The pericarp of this variety differs very little from that of *C. Pepo*, the chief difference being in the greater hardness of the rind.

1. *Epicarp* (*epi*).—The palisade layer is about 36 μ in height, the thickened, prismatic cells having cuticularized outer and radial walls. The outer wall is not uniformly thickened; instead it has a depression over each cell, giving it a wavy contour in cross-section.

There are two forms of hairs, resembling those of *C. Pepo* in size and shape; instead of falling off, however, they persist on the mature fruit. Sunken stomata (*sto*) are present in considerable numbers.

2. *Hypoderm* (*hy*).—The cells of this layer resemble those of *C. Pepo*, the description given for that species applying to this.

3. *Outer mesocarp* (*st*).—This characteristic layer consists of many layers of stone cells which differ considerably in size. The cells are polygonal, small in the sharply defined outer layer, increasing in size inward until they are lost in the next cell layer. About spherical cavities (*x*), occurring at the junction of this layer with the hypoderm, the cells elongate radially to about twice their transverse diameter. These cavities are really large intercellular spaces appearing in the young fruit and showing no evidence of secreting cells in any stage of growth. Before the walls thicken the cells bulge out into these cavities. Among the smaller polygonal cells are also large spherical

ones with cell cavity, frequently 150 μ in diameter, about the size of the intercellular cavities, both being conspicuous. The cell walls vary from 8–14 μ in thickness and have numerous pits.

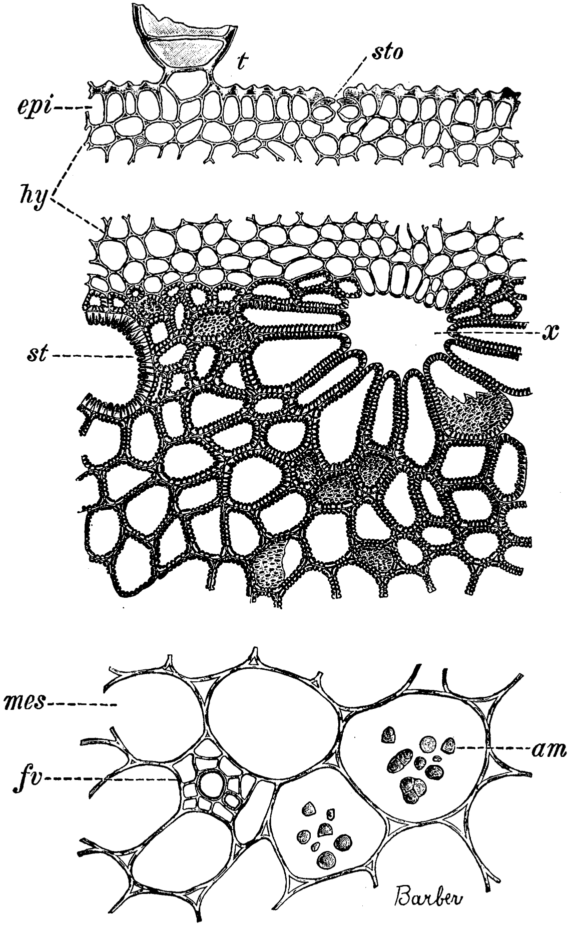


FIG. 7.—*Cucurbita Pepo* var. *verrucosa* Naud. Pericarp in cross-section; *epi*, epicarp with *t*, hair, and *sto*, stoma; *hy*, hypoderm; *st*, outer mesocarp (stone-cell layer) with *x*, spherical cavity; *mes*, middle mesocarp with *fv*, bundle, and *am*, starch. ×160.

4. *Middle mesocarp* (*mes*).—The middle layers of the mesocarp consist of rather thick-walled cells containing numerous truncated starch grains (*am*).

5. *Inner mesocarp.*—The cells of the inner layers are the same size as those of the middle mesocarp, but have thinner walls, larger intercellular spaces, and no evident contents. The fibrovascular bundles, sieve tubes, and latex tubes, found throughout the tissues, are of the usual type.

6. *Endocarp.*—This layer corresponds with that of the species already described.

SPERMODERM.—This differs from that of *C. Pepo* only in the first and fourth layers, as follows:

1. *Epidermis.*—The thickenings on the radial walls, besides branching profusely at the outer end, send out occasional fine branches the whole length of the rod.

4. *Parenchyma.*—The second layer of this parenchyma is four or five cells thick, with somewhat smaller intercellular spaces than in *C. Pepo.*

C. PEPO VAR. MELOPEPO L.

The popular name (scallop) for this variety suggests the shape of the fruit. It is a large depressed berry with ten to fifteen quite deeply cut longitudinal grooves. Like *C. Pepo* it is firm, smooth, and yellow, with a rind and a central cavity containing fibers.

The seeds are elliptical, $1\text{–}1.5^{\mathrm{cm}}$ in length, smooth, flattened, bordered, and of a yellow-white color.

PERICARP.—The cell structure does not differ essentially from that of *C. Pepo.*

SPERMODERM.—This coat differs slightly from the corresponding coat of *C. Pepo.* The palisade layer, with thickenings like those of the variety *verrucosa*, is thicker, reaching 0.3^{mm} on the flattened surface of the seed.

The *raphe*, which in the species previously described is found only around the edge of the seed, here sends out a few branches over the sides. In cross-section the cut surfaces of these branches are quite evident in the inner parenchyma.

C. PEPO VAR. OVIFERA NDN.

The fruit of this variety is egg-shaped, $8\text{–}10^{\mathrm{cm}}$ long, of a yellow-white color, with hard rind which dries up and persists in its original form. The rind is 1^{cm} thick surrounding the central mass of fibers, which do not break down. A cavity is formed, but it is not so evident as in the other species of this genus, since the tissues, although separating, retain their original position.

The seeds are of the usual type for this genus.

PERICARP.—The layers are essentially like those of the variety *verrucosa*, having a wavy-walled *epicarp*, thick-walled *hypoderm*, *outer mesocarp* of stone cells with the characteristic cavities and large spherical cells, *middle mesocarp* with starch, etc.

SPERMODERM.—The layers are similar to those already described.

C. PEPO VAR. ORANGINA SER.

The fruit of this variety differs from that of the type only in macroscopic appearance, having the size, shape, and color of the orange. Rigidity is given the thin rind by the *outer mesocarp* of stone cells.

The small seeds are histologically like those of the preceding variety.

CUCURBITA MAXIMA DUCH.

This species (winter squash) is a native of southern Asia and, like *C. Pepo*, has many varieties differing in size and shape.

The fruit, the largest of the family, varies from 15 to 90^{cm} in length. It is rounded ovate, with warts and occasional longitudinal grooves, and is of a yellow, orange, or green color. In the so-called "turban" variety, the top of the fruit projects beyond an encircling line, or constriction, which marks the margin of the adherent receptacle. The hollow rind with central cavity is filled with bundles and seeds.

The white seeds are 1.5–2.5^{cm} long, smooth, and flattened, with a border.

Both fruit and seed closely resemble in structure *C. Pepo* and its varieties.

PERICARP.—The thin *epicarp*, small-celled *hypoderm*, sclerenchymatized *outer*, thin-walled *middle*, and *inner mesocarp* are like those of *C. Pepo* var. *verrucosa* (*fig. 7*).

SPERMODERM.—The chief difference between this coat and that of the species already described is in the middle spongy parenchyma, which in this seed is five to six cells thick.

CUCUMIS SATIVUS L.

Cucumis sativus L. (cucumber) occurs native in the East Indies, and from this species have been derived many varieties which have long been cultivated in gardens.

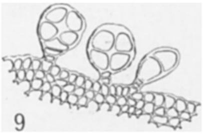
The fruit varies in size, but is always elongated or oval, and rounded triangular in cross-section. It is fleshy and solid, without a central cavity, and of a yellow-white color with white fruit-flesh. Numerous warts cover the surface, each capped with a short blunt spine which readily becomes detached during growth or on handling.

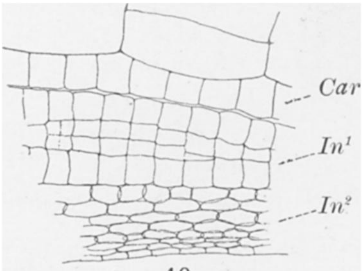
Numerous white seeds (*fig. 8*), borne within the three locules, are $1–1.5^{cm}$ in length, flattened, seldom over 2^{mm} thick, and are not, like those of Cucurbita, provided with a border.

FIG. 8.—*Cucumis sativus* L. Seed. ×1.

PERICARP (*figs. 9, 11*).—This consists only of the solid fruit-flesh, the bundles occurring throughout the mesocarp and not in a central cavity.

1. *Epicarp* (*epi*).—The prismatic cells form a palisade layer $75\,\mu$ in width, with strongly thickened outer and radial walls, and very thin inner ones. The intense color of the fruit is due, not to the cell contents, but to the yellow walls.





10

FIG. 9. *Cucumis sativus* L. Immature epicarp in cross-section, with glandular hairs. ×160.—FIG. 10. *Cucumis sativus* L. Immature seed in cross-section; *Car*, inner carpellary layer; *In*¹, outer integument; *In*², inner integument. ×200.

The warts, which appear before fertilization of the flower, have the same cell structure as the outer layers of the pericarp. Each bears an emergence (*fig. 11*) consisting of large cells with thickened, sparingly pitted walls. They grow rapidly for a short time, but lose their contents soon after their walls begin to thicken.

At its apex the emergence bears a long, jointed (up to ten cells), conical hair, with thickened walls. The cross walls and inner sunken foot, also thickened, are pitted (*t*).

Occasionally a second hair, similar in structure but of smaller size, is developed at the side of the terminal one. The hairs usually disappear in the early stages of growth, but the emergence, unless rubbed off, persists as a brown hyaline spine.

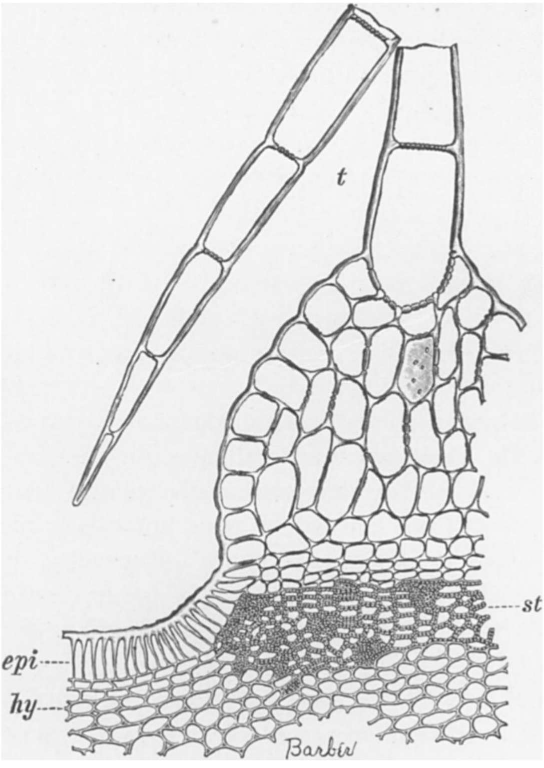


FIG. 11.—*Cucumis sativus* L. Pericarp in cross-section; *epi*, epicarp with emergence bearing *t*, hair; *hy*, hypoderm; *st*, sclerenchymatized cells at base of hair. ×55.

In addition to the hairs of the wart, numerous small capitate hairs, consisting of a four-celled head and stalk of three cells, cover the immature fruit, but disappear early, leaving no scars. Stomata are not present.

2. *Hypoderm* (*hy*).—A number of layers of small, rounded, loosely arranged cells form the subepidermal tissues. In the young fruit they are filled with chlorophyll grains which entirely disappear at maturity.

At the base of the emergence occurs a group of hypodermal cells which become thickened, sclerenchymatized, and pitted (*st*). This thickening of the cell walls probably serves either to prevent evaporation, or entrance of fungi, or both, after the removal of the emergence. In leguminous seeds there are sclerenchyma cells immediately below the hilum groove which serve this same purpose.

3. *Outer mesocarp*.—MOELLER[22] finds a weakly developed stone

---

[22] Mikroskopie der Nahrungs- und Genussmittel 473.

cell layer. In the many fruits I have examined, however, the mesocarp does not show any great differentiation. The outer layers consist of rather small thin-walled cells with intercellular spaces.

4. The *middle mesocarp* differs from the outer only in the greater size of the cells.

5. In the *inner mesocarp* the cells become smaller, resembling those in the outer mesocarp. The bundles, isolated sieve tubes, and latex tubes, found throughout the mesocarp, are of the type already described.

6. *Endocarp.*—The elongated, thin-walled cells of this layer remain with the mesocarp and are not attached to the seeds as in Cucurbita.

SPERMODERM (*figs. 10, 12–14*).—Seeds for study should be taken directly from the fruit, as in drying they usually lose their outer walls.

1. *Epidermis* (*fig. 12, ep*).—The prismatic cells are radially elongated to 160 μ on the sides of the seed and 260 μ at the edge. In surface view they are polygonal, transversely elongated, and arranged side by side in rows. The outer and inner walls are thickened, the outer having in addition a cuticle, while the radial walls are very thin, with the characteristic thickenings on only the side walls. Each thickening consists of a single straight rod, broadened at the base and tapering rather abruptly into a blunt almost rounded point just within the cuticle. VON HÖHNEL,[23] in the year 1876, described these rods as consisting of two different layers; FICKEL,[24] the same year, found three; and HARZ,[25] although quoting VON HÖHNEL, pictured three. My own observations corroborate FICKEL'S statement. The three layers can be distinguished by the difference in refractive power and by staining. The inner layer, which gives the color reaction for lignin, shows the strongest refraction; this is surrounded by a thin layer of cellulose (blue with iodin and sulfuric acid) of rather weak refractive power; and this in turn is inclosed in a broader, scarcely visible, second layer of cellulose (also taking the blue stain). Tangential sections show the arrangement of the layers and the elliptical appearance of the cut rods.

[23] *Loc. cit.*, footnote 3, p. 330.

[24] *Loc. cit.*, footnote 2, p. 742.

[25] *Loc. cit.*, footnote 7, p. 773.

2. *Subepidermal layer* (*sub* and *fig. 13*).—On the flattened surface of the seed this tissue consists of one layer of longitudinally elongated cells, arranged end to end in rows, while at the edge they are somewhat shorter and form several layers. They are quite large, ranging from 50–175 μ in length, and have thickened and sclerenchymatized sinuous walls. The most striking feature of the layer, best seen in surface view, is the intercellular spaces which occur in great numbers between the side and end walls. They are very small, several occurring in every turn of the sinuous wall, which is greatly thickened about the space. Between these spaces and also in the outer and inner walls are small pits.

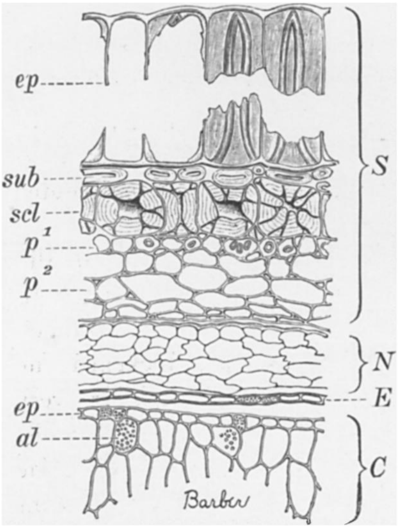


FIG. 12.—*Cucumis sativus* L. Seed in cross-section. *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, p^1, stellate parenchyma, p^2, spongy parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon consists of *ep*, epidermis and mesophyll with *al*, aleurone grains. ×160.

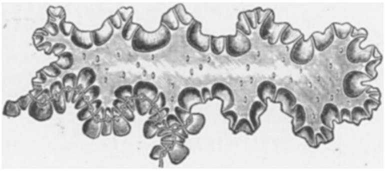


FIG. 13.—*Cucumis sativus* L. Isolated subepidermal cell of spermoderm in surface view. ×300.

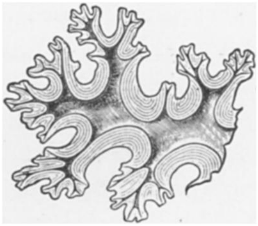


FIG. 14.—*Cucumis sativus* L. One-half of isolated cell of sclerenchyma layer in surface view. ×300.

3. The *sclerenchyma* (*scl* and *fig. 14*) consists of one layer (more toward the edge) of longitudinally elongated (220 μ) cells with narrow cell cavities and very thick lignified walls. Heating with potash brings to view the middle lamella and striations of the wall, but

only after maceration can the overlapping branches of the ramifications be seen. Pits are numerous.

4. *Parenchyma.*—The outer layer (p^1) is one cell thick at the side, increasing in number toward the edge, and consists of small cells more or less stellate in form. This layer is followed by two or three cell layers of thin-walled parenchyma (p^2), which are usually ruptured in dry seeds.

5. The *inner epidermis* consists of small, elongated parenchyma cells.

PERISPERM (*N*).—A number of layers of collapsed, thin-walled cells form this layer. The longitudinally elongated epidermal cells have a cuticle.

ENDOSPERM (*E*).—The cells of this layer are polygonal, 22 μ in diameter, have thickened walls, and contain small proteid granules.

The EMBRYO (*C*) lacks distinctive features.

CUCUMIS MELO L.

All the varieties of musk melon are derived from a single species indigenous to Africa and Asia. HARZ divides the species into nine groups, each with one to ten subspecies.

The fruit varies somewhat in size and shape, but is usually spherical, oval, or occasionally elongated, and has eight to ten longitudinal grooves, differing in depth in different specimens, to which is due the characteristic "melon shape." The surface is green, yellow, or red, with a gray network of corklike tissue.

A rind 2.5 to 5^{cm} thick, with yellow to reddish fruit-flesh, incloses a central cavity containing fibers, seeds, and a considerable amount of watery fluid.

The seeds are like those of *C. sativus*, except that their color is yellow.

PERICARP (*figs. 15–17*).—This consists of the hard rind, and the soft, sweet watery fruit-flesh with bundles.

1. *Epicarp* (*epi*).—The cells of this layer vary in size, shape, and thickness of walls. On the ribs there is a palisade layer of greatly thickened, polygonal cells with a cuticle. In the grooves the cells increase in size, the walls become thinner, and pits make their appearance. In cross-section the cell cavity appears flask-shaped, the

neck running out to a point. *Fig. 15* shows the radiating cell cavity in tangential section.

According to MOELLER,[22] cork cells occur here and there below the epicarp. This I find to be true of the young fruit, but at maturity they break through the epicarp, forming the corky ridges or netted thickenings previously mentioned. The cells are small, thin-walled, and radially arranged, forming a dense mass of cork tissue, which, together with the ruptured epicarp, closely resembles lenticels, but no complementary cells are formed. This likeness is very marked in cross-section (*fig. 16*).

Stomata (*fig. 17*, *sto*), with guard cells of the usual type, are present in the grooves and, less frequently, in the depressions between the corky ridges. The walls of the accompanying cells have few or no pits and are irregularly thickened. In some instances the whole wall is thickened, while in others large protuberances are sent out into the cavity.

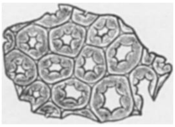


FIG. 15.—*Cucumis Melo* L. Epicarp in tangential section. ×160.

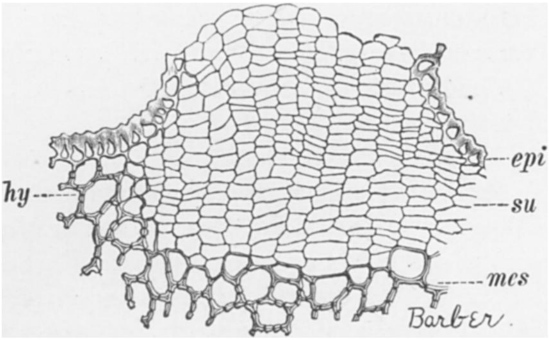


FIG. 16.—*Cucumis Melo* L. Rib of pericarp in cross-section; *epi*, epicarp; *su*, cork; *hy*, hypoderm; and *mes*, mesocarp. ×50.

In the depressions and grooves are jointed (three or more cells), conical hairs up to 375 μ in length (*t*). The diameter at the base is the same as that of the neighboring cells, but gradually diminishes to the apex. The thickened walls have additional minute local thickenings or warts, visible only by the most careful focusing. About the hair scars the cells are distinguished by the smaller cavities and thicker walls.

The immature fruit bears small capitate hairs like those of *C. sativus*.

2. *Hypoderm* (*hy*).—The cells of a number of layers beneath the epicarp are thickened and pitted. Below the thick-walled epidermal cells they are of medium size with intercellular spaces; under the thinner epidermis of the grooves, through which they are visible, they are larger and thinner-walled with very large pits. Chlorophyll is present in greater or less amount even though the fruit appears yellow.

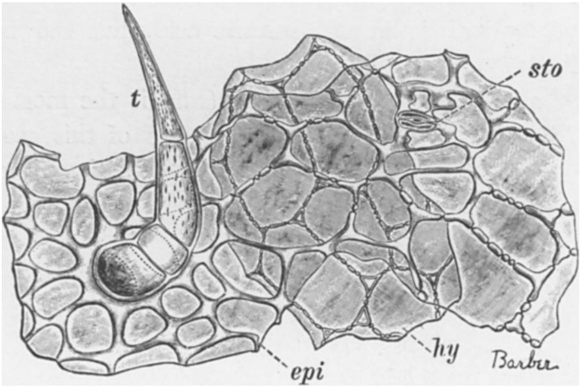


FIG. 17.—*Cucumis Melo* L. Pericarp in surface view; *epi*, epicarp with *t*, hair, *sto*, stoma; *hy*, hypoderm. ×160.

3, 4, 5. The *outer*, *middle*, and *inner mesocarp* of this species consist of cells similar to those of the corresponding layers of *C. sativus*. The placentae, however, instead of persisting intact, are almost if not quite broken down.

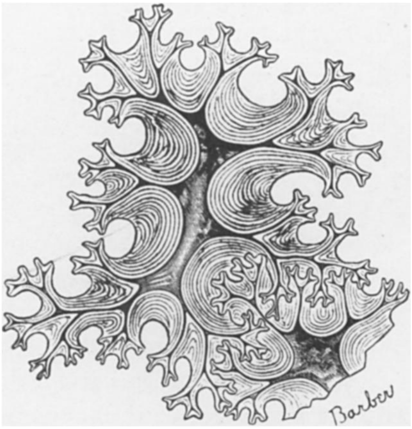


FIG. 18.—*Cucumis Melo* L. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, p^1, sclerenchymatized spongy parenchyma, p^2, spongy parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. ×160.

6. *Endocarp*.—As in *C. sativus*, the cells are thin-walled and longitudinally elongated.

SPERMODERM (*fig. 18*).—1. *Epidermis* (*ep*). Seen in surface view the cells are polygonal and in cross-section they reach a length of 200 μ. The outer wall is thickened and the thin radial walls have the characteristic thickenings. HARZ[26] figures this layer with rods having small side branches at right angles, and MOELLER[22] describes them as simple rods without branches. Like the latter author, I find single straight rods, one on each radial wall, which stain yellow with iodin and sulfuric acid, thus showing them to contain lignin.

---

[26] *Loc. cit.*, footnote 7, p. 777.

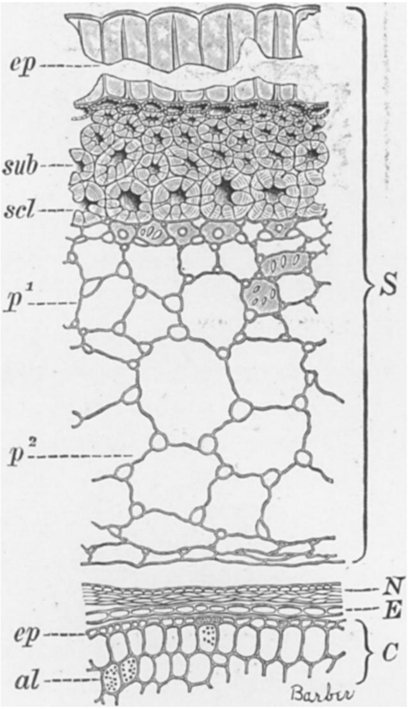


FIG. 19.—*Cucumis Melo* L. Isolated sclerenchyma cell of spermoderm. ×300.

2. The *subepidermal layer* (*sub*) is the most characteristic layer of this seed. Whereas in *C. sativus* it consists of but one cell layer, in this species it has five or six layers of cells longitudinally elongated (except at the edges) and arranged end to end in rows. Both species have sinuous walls and characteristic circular intercellular spaces visible in cross- as well as in longitudinal section. The cells of the outer layer are small, increasing inward in size and thickness of wall with every layer, until the inner one is distinguished from the sclerenchyma only by the somewhat more irregular arrangement and the slightly smaller size of the cells.

3. *Sclerenchyma* (*scl* and *fig. 19*).—This single cell layer differs from that of *C. sativus* only in the irregular contour of the outer surface, where the layer conforms to the shape of the inner surface of the preceding layer.

4. *Parenchyma* (p^1 and p^2).—Beneath the sclerenchyma are one, sometimes two, layers of small cells, which are thin-walled, sclerenchymatized, and frequently pitted. This tissue gradually changes from without inward to larger-celled parenchyma with larger intercellular spaces.

5. *Inner epidermis.*—A layer of small parenchyma cells makes up this layer.

PERISPERM (*fig. 18, N*), ENDOSPERM (*fig. 18, E*), and EMBRYO (*fig. 18, C*) have the same structure as the corresponding parts in *C. sativus.*

CUCUMIS ERINACEUS L.

The seed of *Cucumis erinaceus* L. (*fig. 20*) is $6–8^{\mathrm{mm}}$ long, $2–3^{\mathrm{mm}}$ broad, and $1–1.5^{\mathrm{mm}}$ thick, flattened, pointed, smooth, and yellow.

FIG. 20.—*Cucumis erinaceus* L. Seed. ×1.

SPERMODERM (*fig. 21*).—This is quite similar to that of *C. Melo.*

1. *Epidermis* (*ep*).—The prismatic cells are radially elongated to 70 μ, increasing in length but slightly if at all over the edge. Each radial wall has one rod broadened at the base and bluntly pointed at the outer end.

2. A *subepidermal layer* (*sub*), about six cells thick, consists of small, tangentially elongated cells, increasing in size over the edge of the seed. They are thick-walled, pitted, striated, and increase in size from without inward. Occasional small intercellular spaces are seen, especially at the edge.

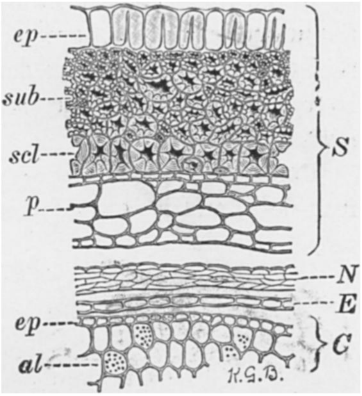


FIG. 21.—*Cucumis erinaceus* L. Seed in cross-section; *S*, spermoderm consisting of *ep*, ribbed palisade epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma layer, *p*, parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon, consisting of *ep*, epidermis, and mesophyll with *al*, aleurone grains. ×160.

3. *Sclerenchyma* (*scl*).—This single-celled layer, 40 μ in width, differs from the subepidermal layer principally in the greater size of the cells, which are longitudinally elongated and have very thick sinuous walls containing pits.

4. *Parenchyma* (*p*).—The outer layer is made up of very small cells with thin walls and small pits seen only with very high magnification. In the middle layers the cells are somewhat larger, also thin-walled, with intercellular spaces at the angles of the cells.

5. The *inner epidermis* consists of one layer of very small parenchyma cells.

PERISPERM (*fig. 21, N*), ENDOSPERM (*fig. 21, E*), and EMBRYO (*fig. 21, C*) present no new features.

CITRULLUS VULGARIS SCHRAD.

Citrullus vulgaris Schrad. (watermelon), now extensively cultivated in the tropics and warmer regions of the temperate zone, is a native of South Africa. ENGLER and PRANTL emphasize the fact that on its native soil the fruit forms a considerable part of the food of both the natives and the larger animals. This view is substantiated by LIVINGSTONE in his *Travels in Central Africa.*

The fruit is spherical, or more often ellipsoidal, of a dark green color, frequently mottled with white in ragged, longitudinal stripes several centimeters in width. The rind is firm but not hard, green at the outer surface, white further inward, changing gradually to the glistening pink, red, or yellow inner fruit-flesh, which contains 91–95 per cent. of water.

FIG. 22.—*Citrullus vulgaris* Schrad. Seed. ×1.

In the inner colored fruit-flesh are imbedded the numerous white, brown, or black mottled seeds (*fig. 22*). They are flat, without a border, lustrous, and smooth except when mottled, in which case they are slightly rough.

PERICARP (*figs. 23, 24*).—The great bulk of the fruit is the solid fruit-flesh, and it is this sweet, watery portion that is usually eaten and not the rind as in Cucurbita. The placentae are beautifully outlined, the bundles being of a somewhat lighter color than the flesh. When very ripe the flesh may separate along these lines, but no true cavity is formed. The individual cells of the inner flesh are visible to the naked eye.

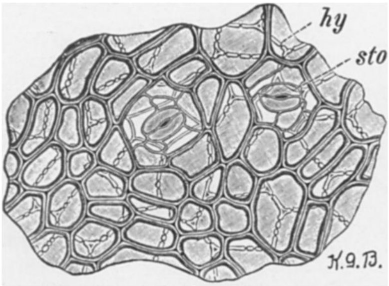


FIG. 23.—*Citrullus vulgaris* Schrad. Pericarp in surface view. Epicarp with *sto*, stoma; *hy*, hypoderm. ×160.

1. *Epicarp* (*epi*).—Instead of the true palisade cells there is a

layer, $33\ \mu$ in thickness, of cells often broader than high. The outer wall is very thick, the thickening running down on the radial walls. In surface view the middle lamella is visible and the hypoderm is quite evident through the thick-walled but transparent epicarp.

The ovary and very young fruit bear jointed hairs, which often reach a length of 32^{mm} but are only $84\ \mu$ broad. They are borne on stalks of several joints, the foot becoming no larger than the surrounding epidermal cells in which it is imbedded. All the walls are only slightly thickened. These hairs disappear soon after fertilization, leaving scars which are evident only on the immature fruit.

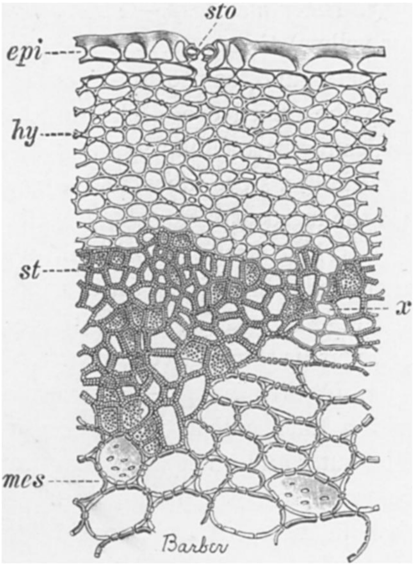


FIG. 24.—*Citrullus vulgaris* Schrad. Pericarp in cross-section; *epi*, epicarp with *sto*, stoma; *hy*, hypoderm; *st*, outer mesocarp (stone-cell layer); *x*, parenchyma between groups of stone cells; *mes*, middle mesocarp. ×160.

Stomata (*sto*) are very numerous, occurring singly or in groups. They have rather large guard cells and thin-walled accompanying cells.

2. *Hypoderm* (*hy*).—A layer, many cells thick, containing chlorophyll, forms the green tissue of the rind. The outer layer consists of short cells, resembling those of the epicarp in size and shape; the following layers are made up of cells smaller in size and isodiametric. Numerous pits are present, the walls appearing distinctly beaded in surface view. Small intercellular spaces occur throughout the tissue.

3. *Outer mesocarp* (*st*).—In the very young fruit the cells are small and isodiametric, but after a few weeks single cells or groups of cells thicken their walls and become pierced with pits. These groups are distributed about the fruit just within the hypoderm. As growth of the fruit continues, these cells increase in number, the groups

approaching each other until there is eventually, in the mature fruit, a distinct zone of stone cells surrounding the inner tissues. This stone-cell layer is not quite continuous, the groups being separated in many places by a few cells which retain their thin cellulose walls and afford easy communication between the hypoderm and middle mesocarp (x). The inner contour of the layer is very irregular.

4. *Middle mesocarp* (*mes*).—The cells are thickened, pitted, and gradually increase in size from the small outer layers inward.

5. *Inner mesocarp*.—This layer is the great central mass of pink (or yellow) tissue. The cells are of enormous size, often 1.25^{mm} in diameter, and, as previously stated, they can be easily distinguished with the naked eye. The walls are thin and are separated at the angles by intercellular spaces. A sweet, watery liquid fills the cavity.

Bundles, sieve tubes, and latex tubes are found scattered throughout the mesocarp.

6. The *endocarp* consists of one layer of small, very thin-walled, elongated cells as in *C. sativus*.

SPERMODERM (*fig. 25*).—This coat, consisting of the usual number of layers, is thin but very firm.

1. *Epidermis* (*ep*).—Prismatic cells form a palisade layer covered with a thick cuticle, which occasionally reaches a thickness of $35\,\mu$. The outer and inner walls have wavy contours, that of the inner wall being much more pronounced. Each radial wall, which is thicker than in the species previously described, has one thickening in the form of a straight rod pointed at the outer end. Occasionally it branches once dichotomously, the two branches running straight out to the cuticle. These rods are sclerenchymatized, responding to the test with iodin and sulfuric acid. In the colored seeds the brown or mottled appearance is due to the colored contents of the epidermal cells.

2. The *subepidermal layer* (*sub*) consists of a number of layers of sclerenchymatized cells, increasing in number over the edges. The outer cells are small and isodiametric; those of the middle layers, large and radially elongated; while the inner cells are noticeably small. The cell walls increase in thickness from without inward, those of the inner layer having scarcely any cell cavities. All of the walls are sinuous and deeply pitted.

3. *Sclerenchyma* (*scl*).—This layer differs somewhat from the corresponding layer of the other cucurbitaceous seeds. Instead of conspicuously elongated cells arranged end to end in rows, they are but slightly if at all elongated and very irregularly distributed, showing only the faintest indications of an end-to-end arrangement. In other respects, that is as regards thickness and sinuousity of the pitted walls, they are similar.

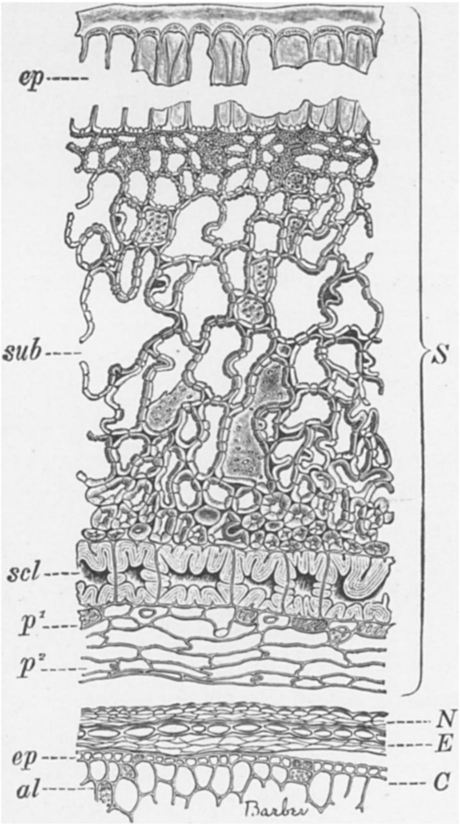


FIG. 25.—*Citrullus vulgaris* Schrad. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, p^1, sclerenchymatized parenchyma, p^2, inner parenchyma; *N*, perisperm; *E*, endosperm; C, cotyledon, with *ep*, epidermis, and mesophyll, containing *al*, aleurone grains. ×160.

4. *Parenchyma.*—One layer of small and somewhat spongy cells forms the outer tissue (p^1). They are thin-walled, pitted, and sclerenchymatized. Below are several other layers of more or less spongy parenchyma, the cells decreasing in size toward the inner epidermis (p^2).

5. *Inner epidermis.*—This layer consists of small, thin-walled cells.

PERISPERM (*fig.* 25, *N*).—An epidermis of longitudinally elongated cells with a cuticle covers a number of layers of thin-walled parenchyma.

ENDOSPERM (*fig.* 25, *E*).—This is the only species studied in which this layer is more than one cell thick. In *Echinocystis lobata* there are occasional broken-down cells below the thick-walled protein layer, but in the present species the cell layers are numerous, forming a tissue as thick as the perisperm. The outer polygonal cells are of the kind described for other species, and the inner layers consist of extremely thin-walled parenchyma, distinguishable only after treatment with Javelle water.

The EMBRYO (*fig. 25, C*) corresponds to that of the general description.

SICYOS ANGULATUS L.

Sicyos angulatus L. is a native of northeastern United States, occurring as a weed in damp places, and is also occasionally cultivated for arbors.

The fruits, each consisting of a small ovate pericarp (up to 2^{cm} in length), filled with a single seed, are borne in capitate clusters on a long peduncle. They are dry and covered with deciduous barbed prickles, $8–10^{mm}$ long, which give them a burrlike appearance.

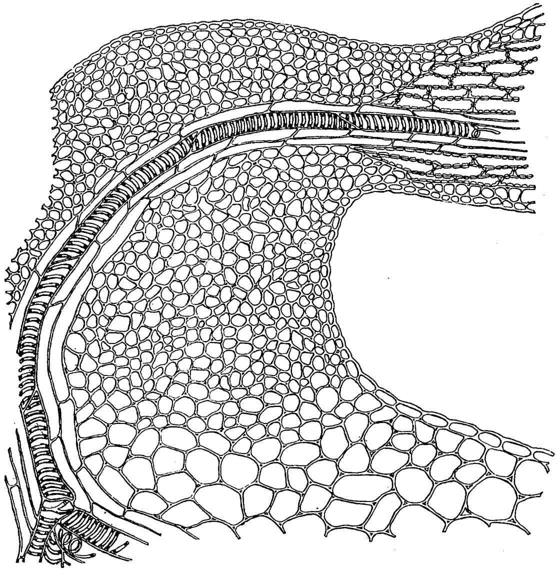


FIG. 26.—*Sicyos angulatus* L. Base of prickle in cross-section, showing characteristic small cells. ×160.

The brown seeds are 12^{mm} in length and 10^{mm} broad, flattened, ovate, smooth, and lustrous.

PERICARP (*figs. 26–29*).—This coat forms only a very thin covering for the seeds and does not make up the bulk of the fruit, as in the other species described. The surface is roughened and covered with spines and hairs, of which, as described below, there are four forms.

1. *Epicarp.*—This layer is composed of small flattened cells 13 μ high, with slightly thickened walls. In surface view they are polygonal and 20 μ in diameter (*fig. 29*).

Very striking are the prickles (emergences), each being a long (8–10^{mm}) outgrowth borne on a swelling of the pericarp (*fig. 26*). They have a constricted base, the epidermis of which consists of thin-walled cells. Above this base the epidermal cells elongate and become thickened. Over all the surface of the prickles are borne slightly curved, single-celled, conical hairs (often 135 μ in length), with extremely thick walls (*fig. 27*). They are very stiff and turn sharply backward. Doubtless they play an important part in the dispersal of the seeds, acting as barbs to fasten securely the prickles, and thereby the fruit, to passing animals. Similar pointed but not deflexed hairs occur on the epicarp, either singly or in pairs.

At the end of the prickle there is a thin-walled capitate hair, consisting of a stalk of several short cells and a single-celled glandular head (*fig. 27*).

Among the prickles there are also large glandular hairs, reaching a length twice that of the emergence (*figs. 28, 29*, t^1). The foot consists of one or two enlarged epidermal cells and is surrounded by cells but slightly smaller. From the foot the cells are elongated and thin-walled, the hair tapering gradually and ending with short glandular cells. The prickles become entangled in the hairs and do not fall off, even though detached from the pericarp.

Another form of hair (*fig. 29*, t^2) on the pericarp is thin-walled, unicellular or several-jointed, reaching a maximum length of 540 μ. The end cell is conical and not glandular as in the preceding hair.

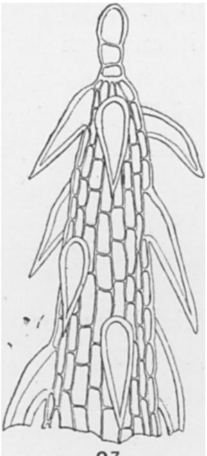
Numerous stomata occur among these hairs.

2. *Hypoderm.*—One or more layers of very small isodiametric cells form an inconspicuous layer just within the epicarp. The hypodermal cells of the constricted base of the prickle are also very minute and thin-walled. These together with the thin-walled epidermis permit the prickle to be readily detached at maturity. In the prickle the cells are elongated and sclerenchymatized, with numerous pits (*fig. 26*).

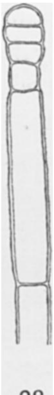
3. *Outer mesocarp.*—Several rows of small rounded cells with intercellular spaces make up this tissue. In the vicinity of the prickles and hairs they are sclerenchymatized and tangentially elongated.

4. The *middle mesocarp* consists of several layers of large-celled, loosely arranged parenchyma with intercellular spaces.

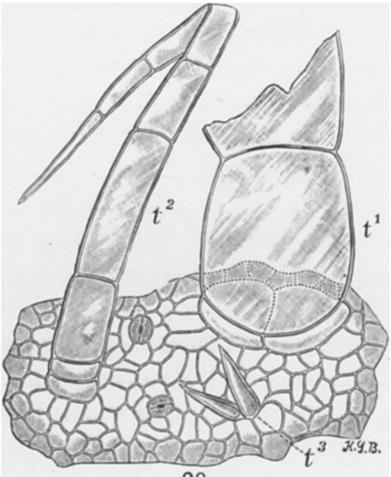
5. *Inner mesocarp.*—The cells of this coat, although somewhat smaller than those of the middle mesocarp, form several layers of similar tissue.



27



28



29

FIG. 27. *Sicyos angulatus* L. Apex of spine. × 160.—FIG. 28. *Sicyos angulatus* L. Apex of long jointed hair. × 160.—FIG. 29. *Sicyos angulatus* L. Epicarp in surface view; t^1, base of glandular hair; t^2, short pointed conical hair; t^3, unicellular conical hair. × 160.

The bundles and latex tubes, few in number, are scattered through the mesocarp.

6. *Endocarp.*—As in *Cucurbita Pepo*, the single layer of longitudinally elongated, thin-walled cells remains on the seed.

SPERMODERM (*fig. 30*).—1. *Epidermis* (*ep*). Prismatic cells form a palisade layer only 50 μ in width. In cross-section no thickenings are apparent on the radial walls, but in surface view, what appeared in the cross-section to be walls thickened at the angles are rods running, one on each wall, from the inner to the outer wall which they seem to join. No cuticle is present; the thickening, however, is continued on the inner wall.

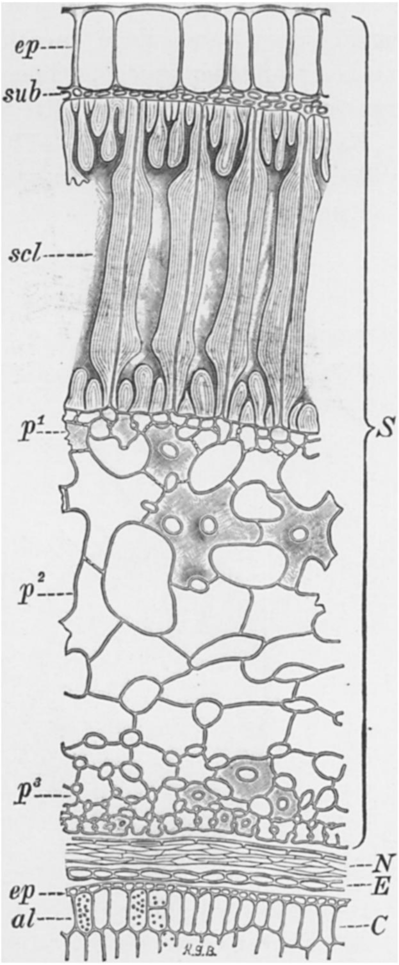


FIG. 30.—*Sicyos angulatus* L. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, p^1, small-celled outer parenchyma, p^2, large-celled spongy parenchyma, p^3, small-celled spongy parenchyma; *N*, perisperm; *E*, endosperm. *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. ×160.

2. *Subepidermal layer* (*sub*).—Small thin-walled cells, 13 μ in diameter, with intercellular spaces, make up one layer. Additional cells of the same type are present below the radial walls of the epidermis, making the tissue two cells thick in those places.

3. *Sclerenchyma* (*scl*).—As in Echinocystis, there is one layer of radially elongated cells forming a palisade layer, 230 μ in width, which is best seen in cross-section. The cell cavities are narrow, constricted about 70 μ from the outer wall, from which constriction branches radiate toward the outer wall. This is repeated at the other end, the constriction being slightly nearer the inner wall. In surface view the cells are sinuous and indefinitely arranged.

4. *Parenchyma*.—The outer cells are small and thin-walled (p^1) and the several middle layers consist of large stellate cells and intercellular spaces (p^2). All of these layers are sclerenchymatized. About ten layers of spongy parenchyma, the cells decreasing in size inward, form the inner tissues (p^3). These cells contain chlorophyll, which gives the tissue a distinct green color.

5. The *inner epidermis* with small, thin-walled cells resembles that of *Cucurbita Pepo.*

PERISPERM (*fig. 30, N*).—Five or six layers of parenchyma, with outer epidermis and cuticle, have the same structure as the corresponding layer of other species. The most characteritsic feature is the transversely elongated epidermal cells.

ENDOSPERM (*fig. 30, E*).—This consists of one layer of thick-walled cells containing protein granules.

EMBRYO (*fig. 30, C*).—No characteristic features are evident.

ECHINOCYSTIS LOBATA TORR. & GR.

This plant, *Echinocystis lobata* Torr. & Gr. (*Sicyos lobatus* Michx., *Momordica echinata* Muhl.), is one of the two Cucurbitaceae indigenous to New England. It has no value as a food, but is quite extensively cultivated for arbors.

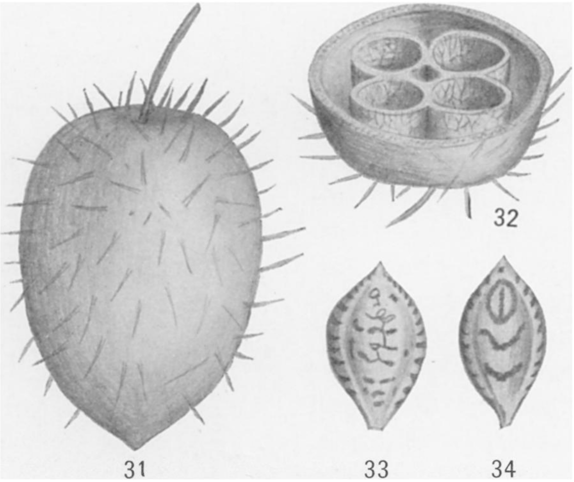


FIG. 31. *Echinocystis lobata* Torr. & Gr. Fruit. ×1.—FIG. 32. *Echinocystis lobata* Torr. & Gr. Fruit in cross-section. ×1.—FIG. 33. *Echinocystis lobata* Torr. & Gr. Seed. ×1.—FIG. 34.—*Echinocystis lobata* Torr. & Gr. Seed. ×1.

The oval fruit (*fig. 31*) is 5^{cm} long, light green in color, and covered with soft spines 12^{mm} in length. At maturity it bursts irregularly at the top, showing the fruit-flesh separated into an outer and inner tissue consisting of a fibrous network. This inner part forms two large oblong cells, each divided at the base into two one-seeded locules, as shown in *fig. 32.* Soon after dehiscence the pod dries up.

The flattened ovate seeds are 20^{mm} in length, 8^{mm} broad, and 4^{mm} thick. The color is gray brown with beautiful brown markings (*figs. 33, 34*) varying greatly on different specimens. On the flattened surface of some seeds these markings are in the form of circles, on others as various shaped spots, but about the edge they generally form a border of elongated diagonally arranged blotches. The embryo differs from the typical embryo only in the greater thickness of the cotyledons.

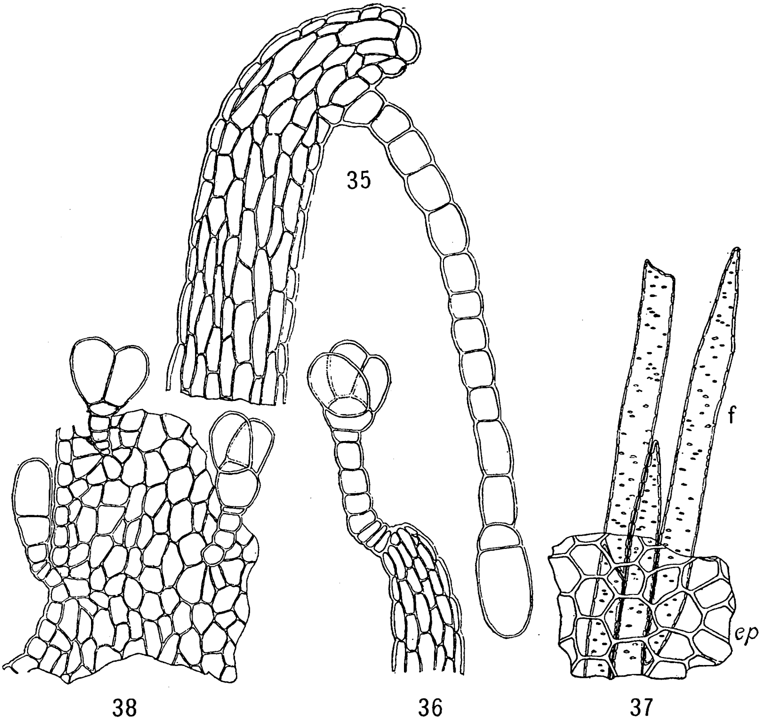


FIG. 35. *Echinocystis lobata* Torr. & Gr. Apex of emergence from immature pericarp. ×160.—FIG. 36. *Echinocystis lobata* Torr. & Gr. Apex of emergence from immature pericarp. ×160.—FIG. 37. *Echinocystis lobata* Torr. & Gr. Mature spine in surface view; *ep*, epidermis; *f*, fibers of hypoderm. ×160.—FIG. 38. *Echinocytis lobata* Torr. & Gr. Base of emergence from immature pericarp. ×160.

PERICARP (*figs. 35–39*).—The outer part, or prickly rind, consists of the epicarp and outer mesocarp, the inner of the hard, stiff bundles with only vestiges of ground tissue.

1. *Epicarp* (*figs.* 37, 39).—The cells of this layer are slightly thickened, in surface view appearing polygonal and distinctly beaded. On the spines the epidermal cells are elongated and have thick walls.

The tip of each spine (*figs.* 35, 36) curves decidedly, bearing at the very extremity, or more frequently just below it, a long, jointed, capitate hair. There is great variation among these hairs. They point downward, upward, or in an intermediate direction; the joints may be few or many, the length of the hair varying accordingly. Each cell is about as long as broad, with moderately thickened outer and slightly thinner cross walls. The head consists of one cell (*fig.* 35), two (*fig.* 38), arranged side by side, or three (*fig.* 36), arranged about a common axis. They have free rounded ends and are elongated, with longitudinal diameter twice that of the transverse.

Similar hairs, but much shorter, with one- to three-celled stalks, are present on the sides of the spine (*fig.* 38). All of the hairs frequently disappear before the fruit reaches maturity.

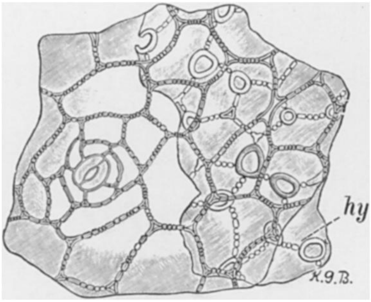


FIG. 39.—*Echinocystis lobata* Torr. & Gr. Pericarp in surface view; epicarp with *hy*, hypoderm. × 160.

Interspersed among the spines are the stomata with small pitted accompanying cells.

2. *Hypoderm* (*fig.* 39, *hy*).—Several layers of pitted cells make up this layer. They are polygonal, thick-walled, and have circular intercellular spaces at the angles, about which the walls are very thick. In the spines the walls are also thickened and pitted, and in addition very much elongated longitudinally. The hypoderm shows through the transparent epicarp, the circular intercellular spaces, with strongly thickened surrounding walls, being especially characteristic.

3. *Outer mesocarp*.—Several layers of isodiametric parenchyma cells form the tissue below the hypoderm. The cells are small and thin-walled.

4. The *middle mesocarp* cells are large, thin-walled, and mostly broken down in the mature fruit, thus forming the cavity between the outer rind and inner fibrous tissue.

5. *Inner mesocarp.*—Groups of small parenchyma cells, with structure similar to that of the middle mesocarp, are found between the bundles.

The numerous large bundles make up the bulk of the mature mesocarp, the anastomosing branches forming the fibrous network. Into each of the spines passes a small bundle which connects with this netted system.

Latex tubes are present in the young fruit, but very few or none are found with the dry bundles of the mature pericarp.

6. The *endocarp* (*fig. 41*) persists on the seed as a single layer of very thin-walled cells, longitudinally elongated and arranged side by side in groups.

SPERMODERM (*figs. 40, 42, 43*).—This thick, hard coat is best studied after bleaching with Javelle water.

1. *Epidermis* (*ep*).—The cells differ markedly from those of the seeds previously described in that they vary greatly in height throughout, owing to irregularities, not in the sur-

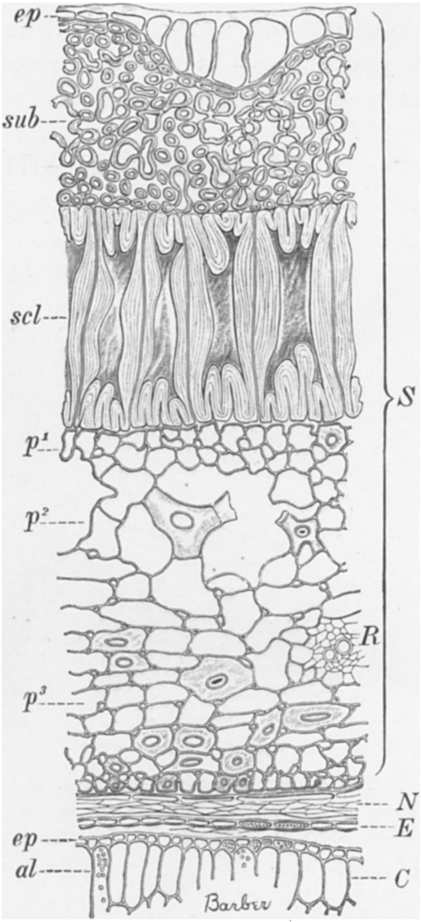


FIG. 40.—*Echinocystis lobata* Torr. & Gr. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, p^1, small-celled sclerenchymatized parenchyma, p^2, spongy sclerenchymatized parenchyma with *R*, raphe bundle, p^3, spongy parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. × 160.

face of the seed, but in the subepidermal layer. A cross-section best illustrates this characteristic feature. The cells are much shorter than broad, except where they suddenly elongate, running down into the grooves of the subepidermal layer to form palisade cells about 54 μ in height. In surface view the whole radial wall is thickened, without the thickened rods so characteristic of other seeds.

2. *Subepidermal layer* (*sub*).—This coat, which varies in thickness, as above described, always consists of numerous (ten to fifteen) layers of sclerenchymatized cells. They are very loosely arranged, with large circular spaces surrounded by thickened walls. In cross-section the tissue appears only as a confused mass of cells, but in tangential section (*fig. 42*) the contour of the walls is very distinct. The seed owes its color to the dark contents of the outer cell layers.

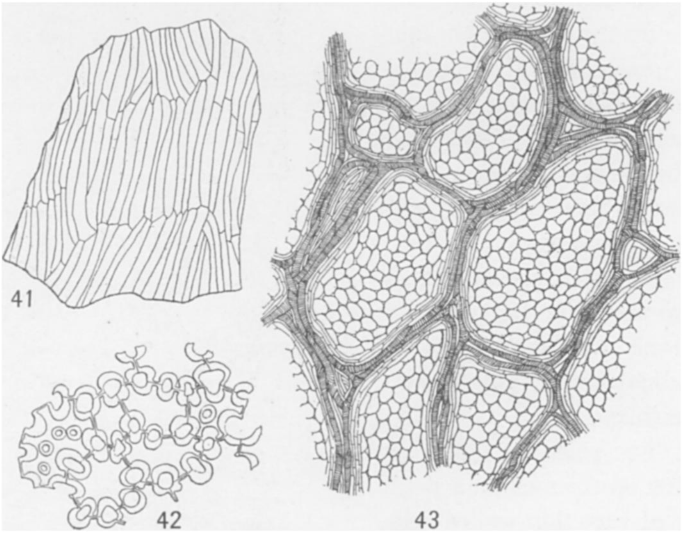


FIG. 41. *Echinocystis lobata* Torr. & Gr. Endocarp in surface view. ×300.—FIG. 42. *Echinocystis lobata* Torr. & Gr. Subepidermal layer in tangential section. ×300.—FIG. 43. *Echinocystis lobata* Torr. & Gr. Parenchyma with raphe in surface view. ×80.

3. *Sclerenchyma* (*scl.*).—In cross-section this single cell layer appears as a palisade tissue, the cells, while only 40 μ broad, being radially elongated to 180 μ. The walls are extremely thick and the

cavities narrow, each sending out branches to the layers above and below. The folds of the sinuous outer and inner walls are also conspicuous in cross-section. In surface view the cells have sinuous walls and are irregularly arranged.

4. *Parenchyma.*—The outer layer (p^1) consists of small, thin-walled, and sclerenchymatized cells without pits. It bears no resemblance to the corresponding layers of Cucurbita. Adjoining this layer are two or three layers of true spongy parenchyma with large cells, thin walls, and large intercellular spaces (p^2). From this tissue the cells decrease in size inward for about fifteen layers (p^3).

The branching and anastomosing *raphe* ramifies through this inner parenchyma. Although each branch contains but few bundle elements, the branches are so numerous that they form a conspicuous tissue, best seen in surface view (*fig. 43*).

5. The *inner epidermis* corresponds in structure to that of *Cucurbita Pepo*, consisting of a layer of small cells with thin walls, the circular contour of the radial walls being very noticeable.

PERISPERM (*fig. 40, N*).—The structure of this tissue is the same as that of the seeds already described, consisting of several layers of thin-walled parenchyma and an outer epidermis with cuticularized outer and radial walls. The epidermal cells are elongated, in many places transversely.

ENDOSPERM (*fig. 40, E*).—One layer of uniformly thickened cells, containing protein granules, forms this coat. In one or two seeds examined there were indications of broken-down parenchyma.

The EMBRYO (*fig. 40, C*) corresponds to the general description, the cotyledons having minute epidermal cells and mesophyll filled with oil and protein granules.

LUFFA CYLINDRICA ROEM.

The smooth, flattened seed (*fig. 44*) is 12^{mm} long, $6–7^{mm}$ broad, and $2–3^{mm}$ thick, of a dark-brown or black color.

SPERMODERM (*figs. 45–47*).—This is thick and consists of the following layers:

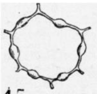
1. *Epidermis* (*ep*).—The palisade layer varies from 30–60 μ in thickness, the outer surface having a sinuous contour. On each of the radial walls is a single rod (*fig. 45*) which, instead of ending free

at the outer end, joins the thickened outer wall. The contents are of a dark-brown color.

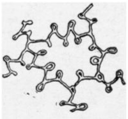
2. The *subepidermal layer* (*sub*) consists of two quite distinct tissues. Within the epidermis is a layer, one to five cells thick, consisting of small reticulated or pitted cells. In tangential section (*fig. 46*) the zig-zag walls are seen to project into the cavity, with an intercellular space in the angle of each projection.

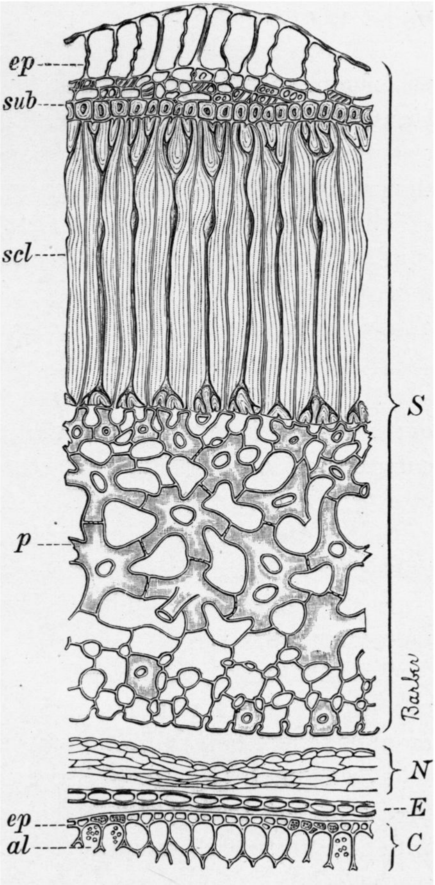
The second tissue consists of one layer of cells, 20 μ in thickness, polygonal and regularly arranged in cross-section, and slightly elongated tangentially.

3. A *sclerenchyma layer* (*scl*) of cells radially elongated up to 235 μ forms this characteristic layer. The outer and inner walls are sinuous, sending out peculiar branches. The cavity, best seen in cross-sec-


45

44


46



47

FIG. 44. *Luffa cylindrica* Roem. Seed. × 1.—FIG. 45.—*Luffa cylindrica* Roem. Tangential section of spermoderm, showing rods on radial walls of epidermis. × 160.—FIG. 46. *Luffa cylindrica* Roem. Tangential section of spermoderm, showing radial walls of subepidermal layer. × 300.—FIG. 47. *Luffa cylindrica* Roem. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, palisade sclerehncyma, *p*, parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. × 160.

tion, is extremely narrow, with a globular enlargement just without the center, the two ends branching and running into pits at the outer and inner tangential walls. In tangential section the polygonal cells are 30–45 μ in diameter.

4. *Parenchyma* (*p*).—A number of layers of large stellate cells form the spongy parenchyma. All the walls are thin, the cross walls being pierced with pits. In the outer layers the walls are sclerenchymatized.

5. *Inner epidermis.*—This layer of small parenchyma cells is also somewhat stellate.

The PERISPERM (*fig.* 47, *N*), ENDOSPERM (*fig.* 47, *E*), and EMBRYO (*fig.* 47, *C*) are of the usual type.

ABOBRA VIRIDIFLORA COGN.

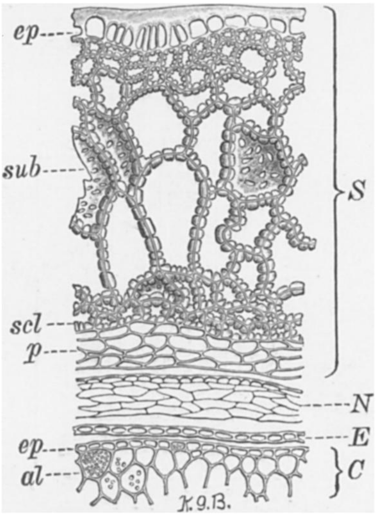
The seed of *Abobra viridiflora* Cogn. (*fig.* 48) is 7–8$^{\mathrm{mm}}$ long, very slightly flattened, the enlarged apex being 2–3$^{\mathrm{mm}}$ broad and 1.5–2$^{\mathrm{mm}}$ thick, of a deep-brown color with longitudinal dashes of a darker brown.

SPERMODERM (*fig.* 49).—Thin but firm.

1. *Epidermis* (*ep*).—The palisade epidermis varies in thickness from 16–45 μ. On the thick radial walls of the larger cells are one or more straight rods joining the outer wall, which is extremely thick.

2. *Subepidermal layer* (*sub*).—This broad layer, six to ten cells thick, consists of very thick-walled, pitted cells irregularly arranged. The outer, and frequently the inner, cells are small, but the middle ones are of enormous size. Few or no intercellular spaces are present.

48



49

FIG. 48. *Abobra viridiflora* Cogn. Seed. ×1.—FIG. 49. *Abobra viridiflora* Cogn. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, *p*, parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. ×160.

3. *Sclerenchyma* (*scl*).—Small, thick-walled, pitted, irregularly arranged cells make up this layer, which has no sharp line of demarkation from the preceding layer.

4. The *parenchyma* (*p*) consists of several layers of small thin-walled cells.

5. *Inner epidermis.*—One layer of parenchyma cells makes up this indistinct inner tissue.

The PERISPERM (*fig. 49, N*) of several cell layers, ENDOSPERM (*fig. 49, E*) of one layer of thick-walled cells, and EMBRYO (*fig. 49, C*) are like those described in the introduction.

MELOTHRIA SCABRA COGN.

FIG. 50.—*Melothria scabra* Cogn. Seed. ×1.

The yellow-white seed (*fig. 50*) is 4–5^{mm} long, 2^{mm} broad, and 0.75^{mm} thick, flattened, pointed, and smooth.

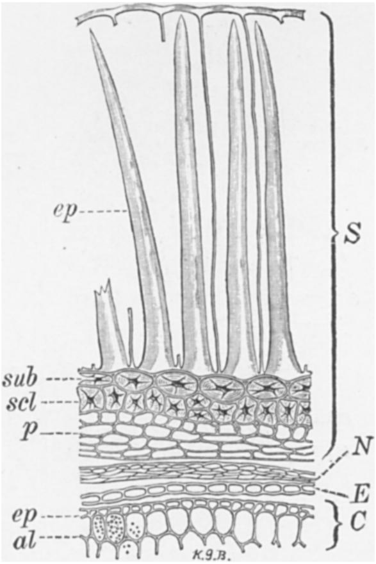


FIG. 51.—*Melothria scabra* Cogn. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*, subepidermal layer, *scl*, sclerenchyma, *p*, parenchyma; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. ×160.

SPERMODERM (*fig. 51*).—Consists of five layers, and has a microscopic structure resembling that of *Cucumis sativus*.

1. *Epidermis* (*ep*).—A palisade layer, 270 μ in width, forms the outer layer, which, as in Cucumis, is frequently absent on the dry seeds. The walls are thin except for a single, straight, pointed rod on each radial wall.

2. *Subepidermal layer* (*sub*).—This single layer is composed of thick-walled cells having pits and distinct laminations. At the edge of the seed the layer increases from two to five cells in thickness, the outer ones being elongated radially.

3. *Sclerenchyma* (*scl*).—Small pitted cells, longitudinally elongated, make up the third layer.

4. *Parenchyma* (*p*).—Several layers of thin-walled parenchyma without characteristic features form the inner tissue of the spermoderm. Only with high magnification can the pits in the outer layer be seen.

5. *Inner epidermis.*—As in the other species, this tissue consists of a single layer of thin-walled cells.

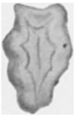
The PERISPERM (*fig. 51, N*), ENDOSPERM (*fig. 51, E*), and EMBRYO (*fig. 51, C*) correspond with the general description.

TRICHOSANTHES COLUBRINA L.

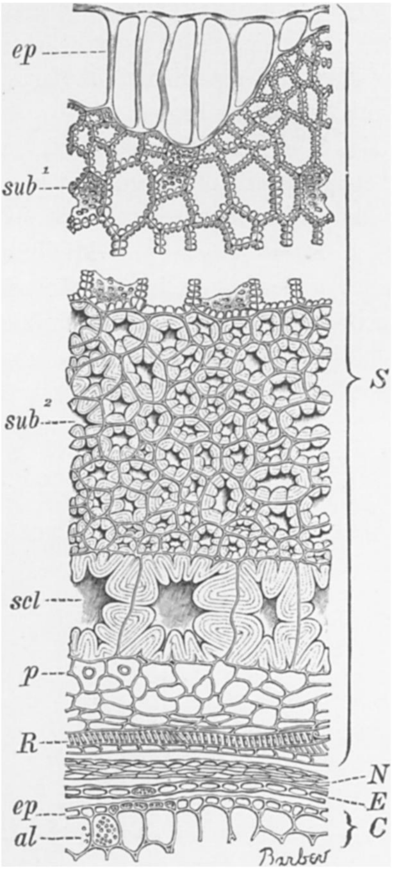
The seeds are 15^{mm} long, 8–9^{mm} broad, and 4–5^{mm} thick, of a gray-brown color. The irregular contour and beautiful dark markings on the flattened surface are illustrated by *fig. 52.*

SPERMODERM (*fig. 53*).—A very hard and thick seed coat with two distinct subepidermal layers is characteristic of this seed.

1. *Epidermis* (*ep*).—This layer is very irregular in width (12–135 μ). The larger cells, running down into grooves of the second layer, bear straight rods on their radial walls. These rods join the thickened outer wall and in cross-section are indistinguishable from the walls at the angles. All of the walls are impregnated with a



52



53

FIG. 52. *Trichosanthes colubrina* L. Seed. ×1.—FIG. 53. *Trichosanthes colubrina* L. Seed in cross-section; *S*, spermoderm consisting of *ep*, epidermis, *sub*^{1}, outer and *sub*^{2}, inner subepidermal layers, *scl*, sclerenchyma, *p*, parenchyma with *R*, raphe; *N*, perisperm; *E*, endosperm; *C*, cotyledon with *ep*, epidermis, and mesophyll containing *al*, aleurone grains. ×160.

brown coloring matter and starch is present in considerable quantity.

2. *Subepidermal layer.*—As previously stated, this layer is divided into two distinct tissues: the outer (*sub*^{1}) consists of cell layers increasing in size from the small outer cells inward, with numerous pits in the thickened walls; below this tissue is a second (*sub*^{2}), many cells thick, consisting of very thick-walled cells with small branching cavities and small intercellular spaces at the angles. The walls of both tissues are brown.

3. The *sclerenchyma* (*scl*), consisting of large, longitudinally elongated cells of the general type, forms a third sclerenchyma tissue which is impregnated with a brown substance.

4. *Parenchyma* (*p*).—Medium-sized thin-walled cells, the outer layer somewhat stellate, make up this layer. Chlorophyll is present in the inner layers in considerable quantity.

The *raphe* (*R*) branches out over the sides of the seed, the small bundles being found throughout the inner parenchyma.

5. An *inner epidermis* of thin-walled parenchyma cells completes the spermoderm.

The cells of the PERISPERM (*fig. 53, N*), ENDOSPERM (*fig. 53, E*), and EMBRYO (*fig. 53, C*) are not characteristic in this species.

YALE UNIVERSITY